SEPTEMBER 2005

# Rock&Gem

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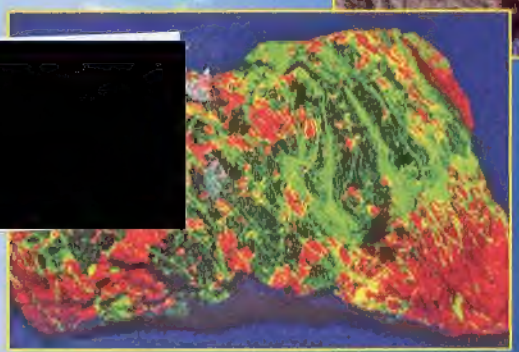
MAKING AND SELLING JEWELRY

# TOURMALINE RAINBOW

ARGENTINA'S CONDOR AGATES

MINERAL CHAMELEONS



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# Rock&Gem

Vol. 35/Number 9 September 2005

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Tourmaline crystals from Maine and from California's Himalaya Mine are from the collection of Bill Larson, Pala International. (Photo by Harold and Erica Van Pelt)


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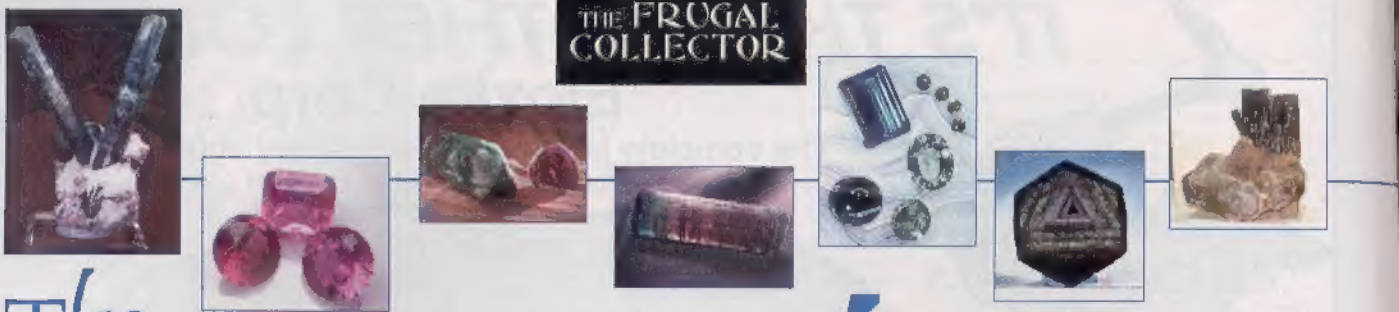


# The Tourmalines

## PART II: Gem Varieties Come in a Rainbow of Colors

Story and Photos by Bob Jones

KRISTALLE, LAGUNA BEACH

**This showy elbaite pair with albite and lepidolite is from the Pedemeira Mine at Minas Gerais, Brazil.**

Though the tourmaline group boasts more than a dozen species. The one that stands out above all others is elbaite, which is found primarily in granite pegmatite deposits. Elbaite develops in rocks that come from many miles down in the Earth's crust. Because of its full array of rainbow colors, you'll come across several names for elbaite: rubellite for the reds; indicolite for blues; and phrizite for black. It can also be called indigolite, siberite, Brazil sapphire, Brazil emerald, and peridot of Brazil!

Liddicoatite is another colorful tourmaline found in pegmatite deposits. It was confused with elbaite for decades, since it also can vary in color, though is predominantly a beautiful red. In fact, the only way to distinguish it from elbaite is to examine it in the laboratory. You seldom see gems cut from liddicoatite simply because it is uncommon and only found in a few places. Liddicoatite's most exciting feature is the unusual internal color zoning it shows when cut into slices.

The vast majority of gem rough from the tourmaline group is elbaite, with liddicoatite providing minor amounts. There are a limited number of gem uvites and dravites, as described in Part I of this article. There are literally hundreds of elbaite-producing complex pegmatite deposits, some of which have been active for decades, some for nearly 100 years! Liddicoatite, on the other hand, comes from a very limited number of pegmatites, mainly the island of Madagascar, which has been referred to as Liddicoatite Island in gem circles.

One of the noticeable properties of elbaite and liddicoatite is their sometimes odd crystal form. Looking down at the top of an elbaite, you will usually see a nearly rounded crystal with bulging sides and a triangular shape. While it normally forms in the hexagonal system, some crystals have a trigonal shape.

Another odd feature of many elbaites is the really deep striations that run in parallel along the shaft of the crystal. These, like the odd, rounded cross section of the crystal, are a function of crystal growth. They develop when the crystal attempts to develop a side prism face, stops, and starts a second and different side prism face next to it. This vacillation between two adjoining prism faces creates deep grooves between them. The striations serve beautifully as an identifying feature of many tourmalines.

SMITHSONIAN

The Himalaya Mine, at Mesa Grande, California, is the source of these large faceted elbaites.

What makes these tourmalines so colorful is the variety of transition metal ions, called chromophores, they might hold. Ions of iron 2+ and 3+ give elbaite its rich green color, shading into yellow-green and even brown. Other tourmalines may get their green color from the chromophores vanadium 5+ or chromium 3+, which also give emerald its luscious green color. Manganese 2+ and 3+ are also chromophores. They are responsible for the pink to red colors seen in elbaite, as well as in liddicoatite. A less important chromophore is titanium 4+.

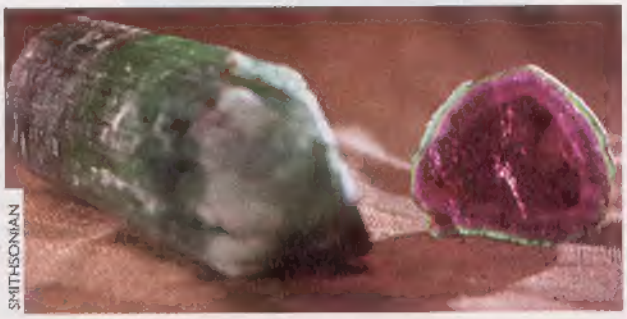
One really exciting elbaite color is due to an oddity. Electric blue crystals from the Sao Jose da Batalha area of Paraiba, Brazil, are colored by copper 2+, the same ions that give turquoise its blue color. It is the first time this element has been seen in elbaite, and the gems are highly sought by faceters. (When we did some work on elbaites from Baja California del Norte, we found an elbaite that had a small amount of zinc in its structure. The color observed, however, was due to iron and manganese, not the zinc.)

One feature that makes elbaite and liddicoatite so appealing is the variation of color within a single crystal. As many as six or seven shades and tints may be seen along the length or across the girdle of a crystal. The obvious reason is that tourmaline gathers in stray ions that happen to be available from the melt, whose chemistry is changing subtly during crystal growth.

Most commonly, the color change involves pink or red and green. The pink and green zoning can either be longitudinal or concentric. Elbaites can also be yellow, blue, brown, and tints in between, depending on the internal chemistry. In 1890, scientist John Ruskin complained, "The chemistry of tourmaline is more like a medieval doctor's prescription than the making of a reputable mineral." But reputable it is, as gem crystals of this borosilicate hold a position of high popularity in the gem world.

The bicolor elbaites are exceedingly popular gemstones. In longitudinally bicolor crystals, opposite ends of the crystal show the contrasting color. The Himalaya pegmatite mine, for example, produces such gems. When faceted, these make lovely elongate, cushion-cut gems, half pink and half green.

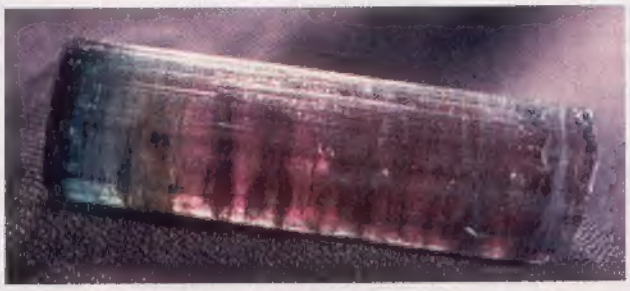
Maybe more exciting are concentrically bicolor crystals. When you cut the crystal across the long axis, the outer "rind" is green and the interior is red or pink. Such crystals are called watermelon crystals. The remarkable multiton find of elbaites at the Dunton Pit at Newry Hill in Oxford County, Maine, in the 1970s produced great quantities of marvelous watermelon crystals, which were both faceted and carved.



SMITHSONIAN

Dug out with a screwdriver, this is the famous 15-inch-long Jolly Green Giant watermelon tourmaline, found in Maine.

Certainly, one of the more exciting color zonings seen in tourmaline crystals occurs in liddicoatite. When cut in cross section, a slice of liddicoatite will show distinct triangular color patterns within the more-or-less rounded hexagonal slice of crystal. This odd pattern is the result of changes in the crystal form during the growth of the crystal; the crystal alternates between developing a hexagonal shape and a trigonal shape. Such changes may be the result of variations in the environment of the pocket in which the crystal is forming.



This choice pink and blue elbaite is typical of the fine gem crystals that come from the pegmatites of Brazil.

Not all tourmaline is pink, as these choice blue elbaite gems prove.

This characteristic was best shown in a 70-pound crystal from Madagascar. Its exterior was an unappealing brown to black. Gerhard Becker, a well-known gem expert from Idar-Oberstein, Germany, bought the huge crystal and cut it at right angles to its length, or long axis. Each slice of the crystal showed distinct triangular color patterns that literally filled the interior of the crystal slices. Photos of these slices found their way into books and museum displays. Since that time, a number of liddicoatite crystals, all showing distinct triangular color zoning, have come from Anjanabonoina, Madagascar, where pegmatites have invaded the Precambrian basement rock. Current production is high not only in pegmatite tourmalines, but in a fine assortment of gem species, as well as superb quartzes and other typical pegmatite accessory minerals.

So what is the difference between liddicoaitite and elbaite? The difference is in the chemistry of the two gem species. Elbaite is a sodium, aluminum, lithium borosilicate. Liddicoatite is a calcium, aluminum, lithium borosilicate. Sodium and calcium atoms are close in size, so when one substitutes for the other, there is little or no distortion of the internal structure.

*continued on next page*

Once liddicoatite was realized to be a distinct species, known elbaite localities immediately became suspect, and searches were made to determine if there was really more liddicoatite out there that had been identified as elbaite. Studies showed, however, that the calcium member of the family was relatively uncommon.

One search for liddicoatite masquerading as elbaite led us to the pegmatites of Baja California del Norte. This site was chosen because its complex pegmatites were rich in calcium minerals and had produced elbaite. What was unusual was that the elbaite was closely associated with danburite, a calcium boron silicate. In fact, specimens of elbaite were found attached to the side prism faces of danburite crystals, suggesting that they had formed simultaneously. It seemed logical to think the calcium that went into danburite's development might also have gotten into the elbaite and substituted for the sodium, making the crystal liddicoatite.

We collected samples and obtained a slice of elbaite to do a microprobe scan examination at Sandia Labs in New Mexico. A microprobe shoots an electron beam at the surface of a mineral. The back scatter from the crystal's surface can be analyzed to determine the elements present. Much to our disappointment, the probe showed the slice of elbaite to be just that, elbaite. There was no calcium, but plenty of sodium. What the probe did show was that the green rind of the slice was rich in iron chromophores, while the pink central core of the slice was rich in manganese ions. It also showed an insignificant trace line for calcium running right at the bottom of the chart, while lithium was well represented high on the scan chart and was dominant in the structure. We found no liddicoatite, but we had a great trip nonetheless!

North of the Baja California pegmatites—actually the same emplacement extends over hundreds of miles—the Himalaya Mine in Mesa Grande is one of the great elbaite producers of Southern California, but it is far from being the only one. The famous Stewart Lithia Mine, like the Himalaya, opened in the early part of the 1900s. It has produced tons and tons of pink lepidolite, a potassium lithium mica. Of greater interest to collectors are the lovely, monochromatic pink elbaites found embedded in the lepidolite. They are often very thin, like a soda straw. Pretty in their own right, when they form radiating clusters to 6 or more inches across and set in a solid background of pink, sparkling lepidolite, they make really attractive and handsome display specimens. The last I heard, the owners of the Stewart Mine were allowing some fee collecting in the site.

Another very important elbaite source in Southern California is the Tourmaline Queen Mine. Like so many pegmatites of this area, it was producing pink to red elbaites in the early part of the 1900s. Around 1913, it yielded a superb specimen that later became known as the Postage Stamp tourmaline. The specimen consists of two free-standing quartz crystals in a diverging arrangement. Nestled between them is a lovely 5-inch pink elbaite with a nice green "cap." The overall appearance of the specimen is perfection. The specimen resided in the Smithsonian collection for decades.

In the early 1970s, the U.S. Postal

**This liddicoatite from Anganabonoana, Madagascar, cut in cross section, shows a distinct triangular color pattern.**

Service decided to select four mineral specimens to be rendered on a set of four 10-cent stamps. Artists went to the Smithsonian and sketched a variety of specimens, from which they could choose the final four. The specimens were returned to the museum while artists developed their final images.

The management at the Smithsonian had no idea which four specimens had been chosen. The elbaite, considered just one of many pretty California tourmalines, became part of a trade for new and perhaps rare specimens, before the artist's renditions for the stamps were released. Once the stamp selections became known, it was too late to retrieve the specimen. After passing through the hands of several dealers and collectors, it ended up in the F. John Barlow Collection. Later, Barlow commissioned a book about his collection, and I served as one of the book's editors. The specimen was featured in several places in the Barlow book. The inside cover shows sheets of stamps featuring the Postage Stamp elbaite. After the publication of this book, one of the more superb color renditions and accounts of a personal collection, the collection was sold and the Postage Stamp tourmaline ended up at the Houston Museum of Science, where you can see it on display. The Barlow book has since become a modern classic and is well worth having in your library.

In 1913, the Tourmaline Queen was not finished producing amazing specimens. The best was yet to come. In 1971-72, the Queen Mine yielded an even more famous set of elbaites, crystal groups that are generally considered the finest examples of American elbaites ever found. By that time, the mine was being operated by Pala Properties International, which also later operated the Himalaya so successfully.

With aggressive mining, a pocket of remarkable elbaites was opened that year. The central pocket was 4 feet across and ranged from 1 to 2 feet high. It was filled with red clay, a common occurrence in California pegmatite pockets. In that red clay, the miners found what have become the best-known California elbaites ever mined. They are called the "Blue Caps": pink crystals topped by a narrow termination layer of intense blue elbaite.

The major specimens from this pocket and smaller adjoining pockets have been given special names. In the Smithsonian is the "Candelabra," a stunning three-crystal cluster of free-standing elbaites on a quartz crystal and albite. I consider it the premier piece from the pocket. Also in D.C. is the "Tugboat," a pair of crystals standing in parallel like the smokestacks on a boat.

The "Rabbit Ears" are two slightly diverging crystals with another small crystal at the specimen base, all attached to fine, large, parallel-growth quartzes. This winner is now in the Houston Museum of Science, along with the Postage Stamp specimen. The "Beer Cans" is a single, nearly round crystal standing vertically with a second crystal the same size lying horizontally across its top termination.

In this country, the first important find of elbaite happened in Maine in 1820. Young Elizah Hamlin and his buddy Ezekial Holmes enjoyed hiking the slopes of nearby hills and mountains. Late in 1820, they were hiking on what became known as Mount Mica, near Paris, Maine. They stumbled upon small, bright green crystals, which were later shown to be elbaite. Between the find and the identification, winter had set in, so the boys had to wait until spring before doing some serious prospecting. By 1822, they mined enough crystals from one pocket alone to fill an oxcart! Naturally, Maine has been a gem hunter's paradise ever since.

Southern California is the other gem tourmaline hunter's paradise, since the area is fraught with pegmatite outcrops, many of which have been mined out and some of which remain to be discovered. Proof of this is the superb finds being made at the Cryo-Genie Mine near Warner Springs, southeast of the better-known Pala District. In the last couple of years, this mine has produced marvelous elbaite crystals in tight, diverging clusters that form a single crystal grouping overall. The dominant color is a lovely soft pink. Successful mining here is being done by Ken and Dana Gochenour. Their finds are being displayed in local museums and at major shows, where they offer specimens for sale. These very recent and quite exceptional specimens have been very popular among collectors and dealers. The Gochenours' exhibit at a recent Tucson Gem & Mineral Show was definitely one of the major exhibits that year. Their mine also produces aquamarine and other species typical of a complex pegmatite.

The number of pegmatites in Southern California that have produced significant amounts of elbaite and other fine minerals is remarkable. The Himalaya, Tourmaline Queen, Tourmaline King, Stewart, Katerina, Hiriart, Vandenburg and Pala Chief mines are just a few of the better known producers. They give the region a ranking as one of the major gem-producing pegmatite regions on the world! Southern California elbaites are always available at shows, and a Frugal Collector can find small representative crystals, particularly thin "pencil" crystals of good color showing hemimorphism. Too small to facet, these can be obtained at reasonable prices.

Of the above-listed California deposits, the most productive in recent years has been the Himalaya Mine. A hundred years ago, it and other mines were major producers. They fed an intense trade in pink tourmalines with China around the turn of the 20th century. The Empress of the Manchu Dynasty loved pink gems. The tourmaline industry in Southern California was so large that, in 1910, 6 *tons* of pink crystals were shipped from there to China. Crystals were carved into fine buttons, snuff bottles, and other items. This trade was stopped by the Boxer Rebellion of 1912. It has been rumored that there were barrels of pink tourmaline crystals sitting on San Diego docks when that catastrophe hit China. I've often wondered what happened to all those lovely gem crystals.

The Himalaya Mine is a dikelike pegmatite that extends through the hill in a nearly horizontal plane, sandwiched within the host norite, a gray fine-grained rock. Its crystals are generally bicolored, often sprinkled with pink lepidolite and associated with or attached to quartz crystals.

When this mine was in high production a few years ago, my son Evan and I were invited to come and dig out a pocket of crystals primarily for an article in *Rock & Gem* (June 1982). After an easy walk into the main tunnel of the mine, we turned left and followed the pegmatite vein until we came to the pocket zone. A pocket had already been breached, and we were able to dig crystals. The pocket was typical in that none of the elbaites were attached to

**This pair of elbaites, called the Steamboat, comes from the Tourmaline Queen Mine and resides in the Smithsonian.**

the pocket walls. This is pretty good support of the theory on pocket explosion. The results of digging that one pocket were interesting: two 5-gallon buckets full of elbaite crystals!

Pegmatites are made up of the same ingredients as granite. In granites, however, the ingredients are dispersed throughout the fine-grained rock mass. There is plenty of evidence that pegmatites form perhaps 10 miles down in the crust of the Earth. With an overlying blanket of solid rock as insulation, they cool very slowly. This gives mineral molecules a chance to find each other, attach, and develop larger grains and, if there is space, crystals. Quartz crystals weighing tons have been found in pegmatites in Brazil, for example.

As quartz and feldspar develop, the remaining watery fluids become more concentrated with elements like fluorine, boron, lithium and the like. Eventually, they develop into species at lower temperatures. The final, highly enriched solutions from the original granite mass are thrust into cracks and openings, where they begin to crystallize. Since quartz can crystallize through a broad range of temperatures, it becomes part of the final crystal development. In fact, it can often be attached to or even pierced by other mineral crystals, including elbaites. So in its final phase, the solution creates tourmalines, beryls, spodumenes and the rare pegmatite species.

As all this is going on, lots of heat is being released. Remember, to convert a liquid to a solid, you remove heat! Because the pocket is usually a closed system, the heat builds and eventually causes the water that remains trapped in the pocket to flash into explosive steam. Steam has much more explosive power than dynamite! This pocket explosion, or eruption, rips the pocket open, allowing weathering products like clay to enter. It also rips crystals from their moorings, scattering them throughout the pocket. Some crystals remain complete, while others are fractured and even broken into sections.

Paul Desautels, then Curator of the Gem and Mineral department of the Smithsonian, once picked up a broken tourmaline that had been dug at the Himalaya Mine some years earlier. He remarked that it looked a lot like a crystal section that was in the Smithsonian collection. Sure enough, the two sections matched, and a complete crystal, though repaired, was added to the Smithsonian collection.

One of the oddities found in a gem pocket on rare occasions is a perfectly smooth, rounded pebble of gem tourmaline. These nodules, as they are called, result from the violent action within the pocket. Once a pocket is opened, it can be subjected to the turbulence of invading solutions, which can grind and tumble the earlier crystal occupants, often destroying them. The tumbling action can also peel off layers of weak growth that made up the original crystal. This spalling reduces a complete crystal to a smaller and smaller unit. What may remain is the gemmy core, or nodule, of the crystal. Because the original growth conditions were the most ideal of the growth cycle, that portion of the crystal is able to survive the ravages of the turbulence. These completely gemmy nodules will cut into large, perfect gems.

One such gem, a brilliant red stone that was faceted into a 255.5 carat beauty in 1777, ended up being the subject of some royal confusion, not unusual in those early days when gem identification depended more on color than science. The gem was given to Russia's Catherine the Great by King Gustave III of Sweden. They both thought the gift was a superb red ruby. It was later proven to be a very fine red elbaite, sometimes called rubellite.

*continued on next page*

Stories of spectacular finds and amazing elbaite crystals abound. Several came from the pegmatite mines of Brazil, where the granite has intruded the Precambrian craton, the core of the continent, to create amazingly rich gem deposits. Most such deposits are discovered when weathering eats away at the feldspar of the pegmatite, eventually releasing weather-resistant quartz, beryl, elbaite, and the like. Loose crystals have often been found in the detritus at the foot of a slope housing the pegmatite source. Of course, prospectors are often aided inadvertently; the underground excavations of burrowing ants or armadillos have brought to light all sorts of gem crystal fragments. In 1967, a pocket at the famous Santa Rosa mines area, which first opened in 1938, was discovered this way. The pocket produced nice bicolor crystals.

The Aracuai-Salinas area of Minas Gerais (some pronounce it Minny's Garage) is probably one of the richest areas for gem tourmalines. The famous Virgem De Lapa Mine has produced marvelous crystals, among them a foot-long green beauty that weighs over 5 pounds! Clearly, Brazil will continue to be a major producer for years to come.

One of the more recent exciting finds of elbaite happened in 1978 at Itatiaia, about 5 kilometers from Conselheiro Pena, a pegmatite-rich area. One pocket produced amazing deep-red elbaites in quantity. The finest crystal from this find was a single crystal about 40 inches long and 8 inches wide, a rich violet-red, and gemmy, certainly one of the great elbaites of Brazil. It was called "The Rocket" by locals. At the time of its discovery it was valued at over $1 million!

There were over 20 producing pockets being worked in that area. The Jonas Mine produced terrific, violet-red, slender, red, gemmy crystals that were in high demand as soon as they were found.

My favorite story involves what was eventually named the Rose of Itatiaia. This remarkable crystal with a lovely snow-white albite skirting weighs 68 pounds, is well over a foot long and 5 inches across the termination, is perfectly terminated, and is a lovely red color. This amazing specimen was named by public ballot at the Tucson Gem & Mineral Show in 1981, the year it was first displayed. When found in the Jonas Mine, it was hanging from the pocket ceiling. It was obviously heavy and space precluded getting enough willing hands up to hold it while prying it loose. The solution was old car tires piled up on the floor below the piece. When pried loose, it settled gently on the tires for easy removal.

The owner of the Rose of Itatiaia is Keith Proctor, who went to Brazil to buy the specimen. Once he bought it, he had a problem. How do you get something that big and heavy back to the United States? Being a resourceful fellow, Keith bought box after box of soap flakes and packed the precious beauty tightly in the white granular material. The crystal arrived safely, and was fun to clean up once uncrated! Keith regularly displays this stunning beauty at major shows, much to the delight of show visitors.

Other Brazilian deposits of note have produced quantities of crystals. In 1961, the mines at Golcanda, one of the country's oldest operating pegmatites, produced a ton of crystals. Two years later, it yielded another 1,000 pounds. I seriously doubt the world will run out of pegmatite minerals—elbaite and beryl in particular—anytime soon.

COURTESY THE COLLECTOR, FALLBROOK, CA

**My son Evan and I had an opportunity to mine fine tourmaline gems at the Himalaya Mine.**

Some of the prettiest elbaites are those that occurred with sharp feldspar crystals at San Piero, Campo, on the Island of Elba, Italy. These elbaites showed lovely colors, including yellow, pink, green, and even black, often in the same crystal. The crystals were never large, up to 2 inches in length, and usually in small clusters on the same matrix. This area produces nothing now.

Aside from Southern California and an occasional find in Maine, the leading sources of elbaites today are in Afghanistan, Pakistan and Africa. Production at the African sources in Kenya, Tanzania, and Klein Spitzkopje is spotty, but is aggressively pursued with good results. Most African crystals are a good red, while the Klein Spitzkopje crystals are dark green. These don't market too well, but if heated, they turn a lovely emerald green and sell very nicely. Almost all the African production is used by the gem industry.

The Pakistan and Afghanistan deposits are producing wonderful specimens, not only of elbaite, but of even more appealing and less common kunzites, aquamarine, and a host of uncommon and rare pegmatite species like cassiterite, and pollucite. One of the earliest quantity sources for elbaites, and one that produced crystals that are still priced reasonably, is the Stak Nala/Shingus area. These elbaites are skirted with bladed cleavelandite. Later sources produced very fine, large elbaite crystals that are suitable for museums and wealthy collectors.

The geology of this entire southern Asian region is fascinating. The deposits are at very high elevations, over 20,000 feet in many cases. The Indian plate banged into the Asian continent, causing uplifting, folding, faulting, and all sorts of geological events, some of which are still ongoing. This action exposed the gem-bearing pegmatites in Pakistan. They date back 50 million years and formed about five miles down.

The few elbaites found some years ago in Nepal are interesting evidence of plate tectonics. They were unknown until 1934, when an earthquake thrust the crust up enough to expose the deposit. Some of these crystals reached 4 inches in length and were multicolored.

Liddicoatite from Madagascar is another example of plate tectonics. This huge island is actually a piece of Africa; it was formerly attached to what is now Mozambique, another pegmatite source. The first crystals found in Madagascar were dug from the detritus at the foot of a slope housing a pegmatite around 1900. Yet, liddicoatite as a distinct mineral was not known until the latter part of the 20th century. The colors in liddicoatite are the same as in elbaite, but, as noted earlier, show some spectacular triangular internal zoning.

Conditions in Madagascar are really difficult. Disease, insects, weather, and a host of other factors make mining here difficult. This, in turn, makes Madagascar liddicoatite rather costly. So the Frugal Collector will have to be satisfied with nice elbaites, which are more abundant and certainly as attractive.

The range of values for the various members of the tourmaline family is such that everyone in the collector world—from a millionaire to a beginning collector—can obtain a tourmaline. Not everyone can afford gem crystals, but there are plenty of non-gem crystals to be found at shows. Keeping in mind the unusual properties of some tourmalines, like its hemimorphism, should give collectors something other than gem quality to use as a criterion.

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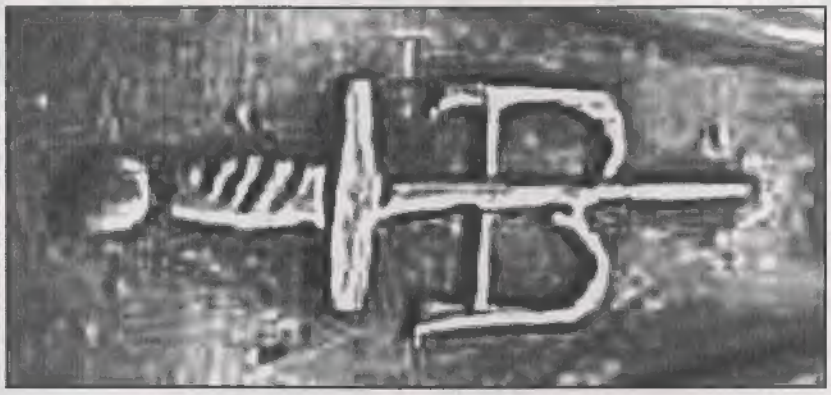
# SHOP TALK

by William A. Kappele

## Hallmarks Followup



In December 2003, at the request of a reader, I wrote a column about using hallmarks on jewelry. This was an interesting experience, since, as I said in the column, I am not a lawyer. In fact, until just recently, I thought Nolo Contendere was an Italian film star. Donald Toney, of Salem, Oregon, *is* a lawyer, as well as a jeweler and gemologist, and he wrote me to clarify a few points.

I said in the column that if you make a brooch for your Aunt Freda and stamp a quality mark (hallmark) on it and do not also stamp a trademark on it, that it is illegal, but that you probably would not be hunted down and incarcerated for the transgression. Mr. Toney pointed out that it is not illegal to omit the trademark unless you want sell the brooch in interstate commerce. It is even permissible for a manufacturer to omit the trademark when engaging in interstate commerce if he uses his real and true name next to the quality mark.

Toney also says state trademarks may be registered inexpensively in most states. In Oregon, for example, the cost is $20. A state trademark does not allow interstate commerce, however.

Another way to gain a trademark is to use the Common Law. This means you can simply stamp a letter T, a letter T inside a circle, or the letters Tm inside a circle next to your logo or company name. If you should decide to use the Common Law system, you should check with the appropriate government office in your state to see whether other rules apply.

Toney suggested that an article or column on copyright law might be of interest to readers, so once again, I went digging on the Internet. It didn't take long for me to realize just what I was digging in. It also didn't take long for me to realize that I was way over my head in legalese and had no business writing about any aspect of the law.

Just for the heck of it, I will give you some of the impressions that I got, but before I start, let me state emphatically that if you have any intention of making jewelry for sale, either locally or in interstate commerce, and if any of it will be a copy of someone else's work or could even be thought of as very similar, see an attorney who specializes in such things before you start. The copyright laws regarding jewelry are written so loosely and are so open to interpretation that any two attorneys or judges could easily and with complete honesty interpret them in opposite ways.

For example, to determine whether your piece has violated someone's copyright, it must show "substantial similarity." This is assumed to mean that an "ordinary consumer" would overlook any differences in the pieces and see the pieces as being the same. Who gets to choose the ordinary consumer? Here are a few questions you should consider:

1. Is the piece you would like to base yours on copyrighted?
2. Do you think that your design is "substantially different" from the original?
3. Should I copyright my piece?
4. Where did I put the Maalox?

There are lots of places on the Internet where you can get even more confused. Just type the key words "copyright law" into your browser and have fun.

Please feel free to contact me if you have a suggestion or comment about this or any of my Shop Talk columns. My e-mail is quappelle@cox.net, or write to me at 25231 Pericia Dr., Mission Viejo, CA 92691.

# MINERAL CHAMELEONS

## Excited Electrons Produce Color Changes

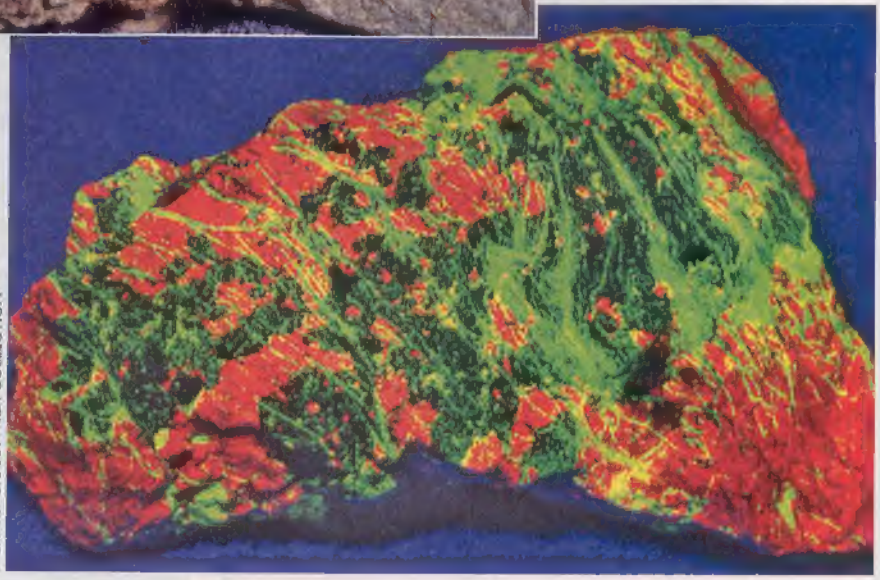
Story by Bill Evans / Photos by Tema Hecht

In 1935, I went to the Yale Peabody Museum in New Haven, Connecticut, on a fifth-grade field trip. Little did I know, that trip would impact my entire life. There was a huge mineral hall displaying the most amazing mineral crystal groups. In a passageway entrance to the hall was a curtained-off display of rocks. In normal light, they were pretty ugly: no crystals, mostly white, gray or black, and dull looking. But push a switch, and these ugly stones did a chameleon act, showing a riot of glowing, bright colors. I had discovered fluorescence and phosphoresence!

I was so intrigued with the phenomenon that I chose "Luminescent Minerals of Connecticut" as the topic for my master's thesis. This gave me a chance to examine more than 70 different sites in Connecticut, mostly at night, for minerals that respond to ultraviolet (UV) energy. That paper was later published and may still be on file in the library at Southern Connecticut State University.

The phenomena of fluorescence and phosphoresence are one and the same, save for one important difference. Fluorescence is seen only when the source of excitation, the UV lamp, is turned on. Phosphorescence is simply a continuation of the mineral's response to energy after the energy source has been turned off. In some cases, the phosphorescence lasts only a fraction of a second and you don't see it. Phosphoresence occurs as excited electrons return to their ground state slowly enough that a lingering glow, often a different color from that of the initial response, is seen. In a few cases, the internal disruption, or slow return of the electrons in the mineral, takes a longer period of time, and the phosphorescence continues. The original fluorescence is due to the actual shifting of electrons to higher orbitals using the added UV energy.

In this specimen of lean zinc ore from the Sterling Mine, the brown minerals tephroite and sonolite predominate in daylight, while sinuous veinlets of willemite glow under ultraviolet light.



RICHARD C. BOSTWICK COLLECTION

Collecting fluorescent minerals today is even more exciting than it was 50 years ago because of the new lamps that seem so much more powerful due to a newly developed filter. The new lamps seem to bring out responses not seen with the older lamps. The colors seem more vibrant and of truer color.

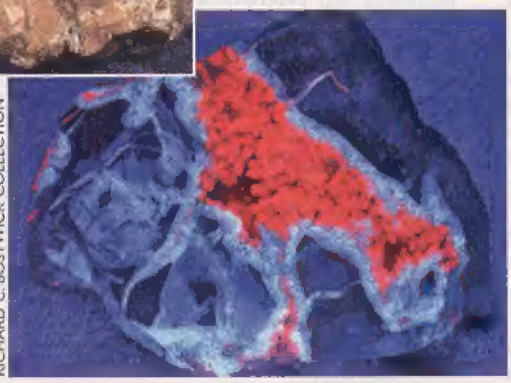
The phenomenon of fluorescence has been known and investigated for a couple hundred years. Now we know a lot about the mechanism that results in a rainbow of colors from several hundred different species. Curiously, a complete understanding of what goes on inside a mineral when it reacts to UV light has still not been obtained. We can offer simple explanations to give collectors some understanding of the atomic event that changes invisible UV energy into a bright, visible color response.

Understand that light is a form of energy containing the colors of the rainbow. When light strikes any mineral, one of several things can happen. The light can be completely absorbed, and the mineral you hold looks black. The mineral may reflect back virtually all the light, and you see white. In the case of most gems, some of the wavelengths of light are absorbed by active electrons in the mineral's structure. Those wavelengths not absorbed produce the color you see. This is true of anything with color.

For example, when light enters an amethyst crystal, some of the energy is absorbed. The absorbed light falls in the lower wavelength range of visible light. The shorter, higher energy wavelengths, those in the violet range, are absorbed the least or not at all, so they pass through the amethyst crystal, giving it a violet color.

When a mineral fluoresces, the difference is that UV energy is not visible to the eye. When you turn on an UV light, it looks purple, but that's just a small amount of high-energy light escaping through the filter. This purple light does not cause minerals to fluoresce. Since UV energy has shorter wavelengths and higher energy than visible light, only certain minerals have the ability to convert this invisible higher energy to visible light. So, the difference between a mineral that fluoresces and one that does not lies only within minerals that respond to the more powerful UV energy source.

Calcite and aragonite fill cracks and crevices in concretions from Worland, Wyoming. The activator manganese causes the red glow.



RICHARD C. BOSTWICK COLLECTION

There are three reasons you see a color response from minerals under UV light. The most common reason is that they contain an elemental trace impurity that is called an "activator" because it activates a color response to UV energy. One common example is manganese, which often causes a mineral to fluoresce red.

The second reason is that one of the chemical elements making up the composition of the mineral is excited and acts as an activator. A good example is the lead carbonate mineral cerussite, a common mineral resulting from the breakdown of a primary lead mineral, mainly the lead sulfide galena.

Cerussite is one of the most widespread secondary lead minerals. It is normally found as beautiful white prismatic crystals, often twinned. It can be tinted by an activator impurity: bluish if it contains some copper, yellowish or reddish if some form of iron. Some white cerussite will fluoresce under UV because the lead atoms that are part of the mineral's normal composition act as an activator. The color you see is usually a nice yellow. Not all cerussite fluoresces; if it contains copper or iron as an impurity or as an integral part of the structure, these elements block fluorescence. When a specimen of cerussite is colorless, white or nearly so, you ought to test it with an UV lamp in case it fluoresces.

Manganese and lead are the activators that produce a response in Salton Sea halite under shortwave ultraviolet light.

RICHARD C. BOSTWICK COLLECTION

The third reason some minerals fluoresce is that they have a defect in their internal atomic or molecular structure. The defect can be the result of missing metal ions, or when atoms of another element, not necessarily an activator, crowd into the structure and distort it.

This last situation is the least common. Of course, most minerals do not fluoresce at all no matter what. As you work with minerals and a UV light, you'll also notice metallic minerals don't fluoresce at all.

The reason specimens of a mineral that often fluoresces may not respond is what scientists call "quenchers," like the iron or copper in cerussite. Quenchers are elemental atoms that get into the internal structure of a mineral by substituting themselves for what should be there. Scientists are not sure why or how quenchers work, but somehow they inhibit the movement of electrons that would normally respond to UV energy.

Which brings us to the question of the atomic structure of minerals, their electrons, and the role these negatively charged particles play in fluorescence. Even though the classic diagram used to represent the structure of an atom is a great oversimplification, it helps us understand that electrons orbit the nucleus of an atom in a fairly set position. The nucleus is not involved while these electrons combine to form compounds, cause color, and perhaps respond to UV energy.

The arrangement of electrons around an atom's nucleus is determined by the energy each electron has. Their set positions are really areas called orbitals. Electrons don't normally move from those orbitals unless more energy is applied. We've already said that light, which is just one small part of the electromagnetic spectrum, is energy. So when ordinary light strikes minerals, many of them exhibit a lovely color as their electrons absorb some light energy, move out of position, then emit some of the absorbed energy at a lower energy state. This is seen as a specific color.

It sounds simple enough, but is actually very complicated. For our purposes, it is enough to say that the electrons of any mineral with color have absorbed some light energy. In minerals that respond to UV light energy, these electrons shift because of UV light energy. When the energy source, the UV lamp, is shut off, they shift back and give off a lower level of energy, which we see as a normal color in the gem or mineral. Keep in mind that some of the energy absorbed is lost to motion or converts to heat energy.

*continued on next page*

## Mineral Chameleons *from page 21*

Most minerals that possess color in ordinary light do so because they contain some impurity, or chromophore, that acts like an activator. It is called a chromophore because it absorbs light energy, causing the complimentary color of the energy absorbed to be dominant and visible. Benitoite, for example, is a lovely blue thanks to a trace amount of titanium. Benitoite also fluoresces a lovely red color because of the titanium.

Other minerals have a color because of a trace mineral that is an integral part of the structure. Cobaltian calcite, for example, has a lovely violet red to pink color, but it does not fluoresce because cobalt acts as a quencher! Those same cobalt atoms act as an impurity, absorbing some light energy, shifting, and releasing the remaining energy so we see a red-violet or pink color. The point is that what explains color in regular gems and minerals also explains what happens with minerals that fluoresce. The difference is that minerals that respond to UV can do so because of the presence of an activator capable of absorbing UV energy and releasing it as a visible color. One of the laws of UV minerals is that when UV energy is absorbed it has to be released at a lower energy level, which happens to be visible light.

The color we see is determined by the specific wavelengths of energy given up. Each color is a slightly different wavelength. The only differences between the colors we see in ordinary nonfluorescent minerals and those that respond to UV light are the energy source, invisible UV energy, and the ability of a responsive activator present in the mineral that will fluoresce or phosphoresce. Minerals with color in ordinary light, and minerals that fluoresce under UV energy owe their color to energy-absorbing electrons.

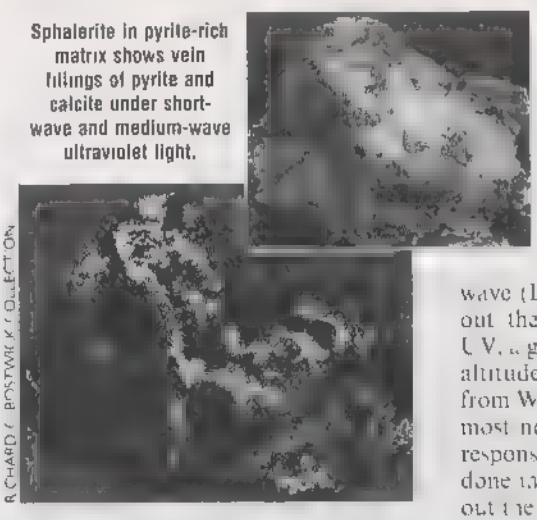
Not all impurities in minerals can act as activators, but there are some with that ability. If only it were so simple. First, a mineral may fluoresce any one of several colors or not at all. Second, the activator in some minerals has never been ferreted out, yet we know there is something doing the job. Finally, in some cases, two or more elements are acting in concert to give the response you see.

Given that, we do know of some elements or radicals (two or more elements acting in concert) that cause a response to UV. Manganese, one of the more common activators, causes the brilliant red response seen in calcite from a number of localities. Mercury is another activator element. In fact, household fluorescent lights use it to produce fluorescent white light.

In diamonds, things like boron may trigger a responding color. The Hope diamond, for example, contains boron and fluoresces a deep, rich red. Chromium gives ruby its red color and causes its red response to UV.

Uraninite, the primary oxide of uranium, does not fluoresce. But a host of secondary uraniums do fluoresce because the uranium in each acts in concert with oxygen as the uranyl radical to cause a yellow or, much more often, a brilliant green response. For example, the uranyl radical gives hyalite opal and common opal a brilliant green color. Many agates and thunder eggs show the same response.

You may wonder if the fluorescent lights that brighten your work place or home are really fluorescing. They are. A fluorescent light tube is a cloudy white, caused by a coating on the inside of the clear glass tube. Electric energy is shot into the glass tube to vaporize the mercury in it, and that excites the white powder coating, which responds by fluorescing white light. When such lights were first developed, the coating was a beryllium compound, a poison. It glowed brilliantly, but if you broke the tube and got cut, that poisonous white powder could get into your bloodstream. Scientists finally figured out that using pure zinc oxide, a harmless compound but a good activator, the poison danger was eliminated and the light, slightly less bright, would work just fine.



Sphalerite in pyrite-rich matrix shows vein fillings of pyrite and calcite under short-wave and medium-wave ultraviolet light.

RICHARD T. BOSTWICK COLLECTION

My favorite group of fluorescent activators causes some delightful color responses in minerals, but the name is difficult to say. It is the lanthanide series, or as they are more often called, the rare earths, so named because they are rare to uncommon and hard to isolate in pure form. The rare earth group includes 15 different elements. They occupy a separate line on the Periodic Table of Elements because they don't quite fit the pattern of properties defined by the chart, but their properties are so similar. They are also considered rare partly because they are found in minerals that are also uncommon. I love their names: lanthanum (La), cerium (Ce), terbium (Tb), ytterbium (Yb), lutetium (Lu), thulium (Tm), holmium (Ho), samarium (Sm), europium (Eu), gadolinium (Gd), dysprosium (Dy), erbium (Er), neodymium (Nd), and my favorite, praseodymium (Pr). We haven't actually found promethium (Pm) yet. Another element that is normally considered a rare earth but listed in the normal sequence on the Periodic Table is yttrium (Y).

What makes some of these rare earths so special is they are the activators in a variety of minerals, the most popular being fluorite, the mineral for which the science of fluorescence is named.

Fluorite is so responsive to UV excitation that it will often glow brightly when held in sunlight, a source of long-wave (LW) UV. The ionosphere filters out the more lethal short-wave (SW) UV, a good reason to preserve that high altitude zone. The English fluorites from Weardale and nearby environs are most notable for a brilliant violet-blue response under the LW lamp. Studies done in England and Scotland ferreted out the rare earths responsible for fluorite's lovely UV colors. These studies on English fluorite were carried out in the early 1950s at the Department of Scientific and Industrial Research Department of the Geological Survey and Museum, Great Britain. The results were reported by K.C. Dunham in a most interesting small text. Among the activators from the rare earth group that cause a significant or strong blue to violet response in English fluorite are Yb, Eu, Ce, Y, Dy, Nd, Gd, and La. In some cases, researchers also found traces of manganese, lead, and even uranium, but they were unable to show they were activators in the fluorite.

An explanation of the electromagnetic spectrum and the differences between SW and LW is now in order. It's common knowledge that energy travels in waves of differing lengths. The distance from one wave peak to the next is called a nanometer, which is one millimeter.

*continued on page 24*

The span of the electromagnetic spectrum includes radio waves, radar waves, heat waves, visible light, cosmic waves, and X-rays. Right next to the visible light waves (about 400 nanometers to 700 nanometers) are shorter UV wave energies (300 nanometers to 400 nanometers).

Scientists divide that small 100 nanometer UV segment of the spectrum into four sections called the far ultraviolet, short-wave ultraviolet, midwave ultraviolet, and long-wave ultraviolet. Of these four, short-wave and long-wave ultraviolet affect the vast majority of minerals that do fluoresce. SW and LW UV are treated separately when describing minerals because they cause different responses in minerals and they are produced very differently in the lamps we use.

LW UV comes from the sun, causing some fluorite to fluoresce and your skin to develop a tan. Any SW energy transmitted by the sun is blocked by the atmosphere, particularly the ionosphere.

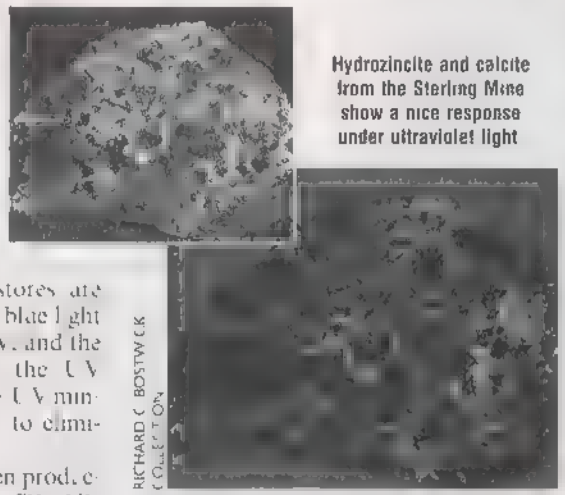
LW light for mineral testing is produced in ordinary blue glass tubes with an interior coating of a phosphor that emits LW UV. The lamps you buy in novelty stores are unfiltered, so lots of ordinary blue light escapes along with the LW UV, and the normal light tends to dim the UV response. Lamps made for LW UV mineral viewing use a glass filter to eliminate the white light.

Things are not so simple when producing SW UV. For one thing, SW UV won't pass through ordinary glass, so SW lamps need a special clear quartz-type glass. The clear quartz glass allows SW and all the white light to pass through it, so the white light must be filtered out with a very costly special filter. The actual SW radiation comes from vaporizing mercury sealed inside the clear quartz tube. Early filters were gradually affected by the strong SW radiation, allowing less and less SW UV to pass through, a process called solarization.

About 25 years ago, a new SW filter was developed that did not solarize anywhere near as quickly as the old filters. The costly new lamps last a lot longer, are a stronger source of SW UV, and have been responsible for a very dramatic renaissance in collecting fluorescent minerals. More and more these days you see collectors walking around shows armed with an SW and LW UV lamp in hand. They use their bodies to block as much ambient light as possible as they check the entire stock of each dealer for color responses.

That reminds me of the early daytime collecting at Franklin, New Jersey, the Fluorescent Mineral Capital of the World. The ore minerals there include dozens of metallic and gangue minerals that fluoresce. Any display of fluorescent minerals you see in a museum tends to be dominated by the brilliant reds, greens, blues, yellows, and oranges seen in Franklin/Sterling Hill, New Jersey, fluorescents.

Using the older, less effective lamps back in the late 1940s and early '50s, we would crawl around under a blanket on the Franklin mine dumps with a dual UV lamp searching for calcite, willemite, hardystonite, calcium arsonite (now called esperite), and much more. Two or three hours under a blanket with the UV lamp, and you'd have a raging headache caused by the reflection of the UV rays from the rock surfaces. Rockhounds will do almost anything, suffer almost any discomfort, to get that one good rock!



RICHARD C. BOSTWICK COLLECTION

**Hydrozincite and calcite from the Sterling Mine show a nice response under ultraviolet light**

Some minerals display other energy phenomena. The nice thing is that no special equipment like a UV lamp is needed to see these strange emissions. UV light is the primary energy source that brings out the best in fluorescent minerals, but X-rays and infrared waves can cause responses, as well. You and I have no access to such technical stuff, but you can get some minerals to glow if you heat them, since heat is an infrared energy source. Some forms of fluorite, for example, will glow a soft greenish color when heated in the oven, be careful, because the fluorite can shatter if overheated. This energy emission is called thermoluminescence. The fluorite that does this is often called chlorophane, a discredited name. I came across a lot of this type of fluorite while investigating brilliantly fluorescing scheelite at the old Trumbull, Connecticut, tungsten mine. The fluorite around Crystal Peak in Colorado will react to heat energy, as well.

Another odd phenomenon is called triboluminescence. You can see this when you vigorously rub two pieces of quartz together in the dark. The friction causes a spark of light again and again, while the quartz seems to glow internally. The quartz from pegmatites seems to do this the best.

You can check sphalerite for triboluminescence by dragging the tip of your rock hammer or any steel point across the surface of the rock. Not all sphalerite will respond, but a lovely orange color may be emitted. This was the technique used by miners in Bisbee to differentiate veins of sphalerite from black copper ores.

The list of minerals that fluoresce and the localities that produce them is really extensive. More than 500 distinct mineral species or their varieties respond to UV, and many of them occur prolifically across the land. You can expect something will fluoresce at virtually any locality.

The best place to go is the historical Sterling Hill Mine and Museum in Ogdensburg, New Jersey. You can take an underground tour and enjoy seeing solid walls of fluorescent calcite/willemite. You can also collect on a dump that is refreshed now and then by underground mining. The highlight for fluorescent collectors is the Thomas Warren Room, which holds a spectacular fluorescent mineral collection. Tom Warren is considered by many of us as the father of modern fluorescent mineral collecting!

You can also collect at the annual Franklin/Sterling Hill Show. Steve Phillips, who lives nearby and owns the Trotter Dump in Franklin, turns the dump every year during snow time and allows collecting for a fee. The results are fruitful and exciting, you have a good chance of finding a nice variety of non-fluorescent and fluorescent minerals. The most popular fluorescent mineral is calcite blessed with one or more activators. Franklin/Sterling Hill calcite usually fluoresces a brilliant red from some small percentage of manganese.

Calcite from the mercury mines in Terlingua, Texas, is even more interesting. Under SW UV, it is a lovely blue. Shut off the SW lamp, and the color persists, slowly fading until you can no longer see it. In LW UV, this calcite is an equally lovely pink, most likely because of mercury.

*continued on page 26*

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## Mineral Chameleons *from page 24*

While Terlingua has been heavily collected and offers little to the collector today, about 20 years ago, my friend Benny Penn obtained superb calcite cleavages that are colorful and transparent. Some of the cleavages are as much as a foot on an edge. This material ranges from colorless to shades of yellow, orange, pink, and green. Under SW excitation, it fluoresces a fine blue with a nice blue phosphorescence, just like the material from Texas. The LW response, however, can be pink or a strong yellow-orange. Luckily, this Mexican source is still producing, though in lesser amounts.

Fluorite is often responsive, but not if it lacks an activator. Fluorite from the mines of England is almost always a lovely blue to purple under the LW lamp, less bright under SW. While the metal mines in England, source of most English fluorite, have long since been shut down, the quantity of blue to purple fluorite retrieved was immense and can still be seen around. Better yet, recently mined at Frosterley, Weardale, fine green fluorite cubes, usually under ½ inch on an edge and tightly packed, fluoresce a fine blue under LW UV. The available supply of specimens is extensive.

Check every fluorite specimen that passes through your hands, because many fluoresce. Some of the fluorites from the limestone quarries in the Midwest contain a trace of bitumen or petroleum, producing a yellow tan, often zoned, response. Fluorite from Mapimi, Mexico, gives a soft red response.

Scheelite played a very important role in the emergence of fluorescence as a vital and useful property. Very fine crystals of scheelite can range from orange to tan to straw yellow to violet and even colorless. But crystals are not common. Scheelite commonly occurs as large, colorless crystalline masses that closely resemble quartz or calcite. The portable SW UV light helped miners discover tons of scheelite on the dumps of California gold mines.

The mineral glows a brilliant blue-white when it is nearly pure calcium tungstate. When molybdenum substitutes for the tungsten, the scheelite gradually becomes powellite, a calcium molybdate. Powellite fluoresces a fine yellow. Since the two minerals form a series, the fluorescent color reveals the percentage of tungsten in the mineral.

China is producing superb orange-yellow to straw yellow powellite crystals on white feldspar. The crystals approach 2 inches on an edge and form pseudo-octahedral crystals that fluoresce a rich yellow.

The trap rock quarries of the Nasik area of India have been yielding powellites since the 1970s. The pseudo-octahedral crystals are tetragonal dipyramida beauties on white stilbite or scolecite. Most are honey-yellow and can reach an inch or so in size. Remarkably, these crystals respond to LW UV, giving off a bright yellow-white. When checking both scheelite and powellite, always test with both LW and SW light, as some scheelite and much powellite may respond to LW UV rather than SW.

While primary uraninite does not fluoresce, the majority of the secondary uraniums do fluoresce, usually green. During the 1950s, when the uranium boom was in full flower in the Four Corners area, prospectors used the Geiger counter and the UV lamp to check for uranium deposits.

For the collector, the most popular secondary uranium mineral is probably some form of autunite, a copper, uranium phosphate. It is commonly seen as small, single, micaceous, green crystals in many pegmatite deposits. America's most spectacular source was Mount Spokane, Washington, long since mined out. Large masses of bladed autunite in cockscomb formation fluoresce a brilliant green. Analysis proved the mineral was actually strontian meta-autunite with small inclusions of black primary uraninite. Autunite is a copper mineral, yet the copper does not act as a quencher.

Every collector will enjoy using a UV lamp. Scan your personal collection, and some of the rocks might show a startling response. Surely, the fluorescence and phosphorescence of minerals adds another interesting dimension to your collecting trips and activities. The initial investment is high, but the colorful results are certainly worth it.

A good source of UV equipment is UV Systems, 16605 127th Ave. S.E., Renton, WA 98058-5549. Another is Anderson Fluorescent Minerals, 1430 Vue Du Bay Ct., San Diego, CA 92109-1931, (619) 488-1420. Check with your local rock shop for more information or books on the subject. A fine book called *Collecting Fluorescent Minerals* by Stuart Schneider, was published in 2004 by Schiffer Publishing Ltd. Full of wonderfully rendered color plates of minerals that fluoresce, the book is a nice introduction to this fascinating aspect of our hobby!

# BRAZIL'S AMETHYST GEODES

## Vast Deposits Surface in Rio Grande do Sul

Story by Brad L. Cross

ANDREW DONNELLY PHOTO AURORA WEST SPECIMEN

Stalactic formations are sometimes found in Rio Grande do Sul geodes

Amethyst, a birthstone for the month of February, is a purple variety of crystalline quartz. It owes its name to the ancient Greek word amesthusos, meaning "not drunken." Ancients believed that wearing amethyst as an amulet would protect you from intoxication and evil spells, calming your spirit and giving you focus. It has been recovered by archaeologists from the burial crypts and ruins of early Egypt and Babylonia. The sources of amethyst for the ancients were most likely India and Sri Lanka (formerly Ceylon). The stone was probably somewhat rare and extremely valuable. The discovery of vast deposits of amethyst in Brazil and Uruguay caused it to be available to most everyone.

Like the Brazilian agate, sparkling amethyst gems are found in Brazil's southernmost state, Rio Grande do Sul. However, the two are never found together. They occur in separate and distinct deposits. The amethyst geode deposits are found primarily in the northern half and in western portions of the state, south of Iraí in the Ametista do Sul (São Gabriel) area, in a very well-defined basalt horizon at 1,300 to 1,450 feet above sea level.

Geode mining in this area dates back to the mid-1800s, when European immigrants discovered and began to work the region's deposits. They shipped tons of agate and amethyst geodes back to Germany as ballast aboard sailing ships. As word of the strikes spread, other deposits were discovered throughout the region. Much of this area was, and still is, nearly impenetrable due to dense forests, and roads, where they existed, were usually quagmires that could not support heavy wagons. As a consequence, the accessible areas were mined first, and even today new deposits of considerable size are being found in Brazil and Uruguay.

The town of Soledade is centrally located in the heart of Brazil's amethyst and agate country. It is the cutting center for the region's gems, and its huge warehouses contain forests of tall, short and wide geodes that tantalize even the most sophisticated viewer. More than 125 million years ago, this region, with adjoining areas of Uruguay, Paraguay and Argentina, experienced extensive volcanic activity, which produced one of the largest discharges of lava on Earth's surface.

The geode-producing geologic formations of Rio Grande do Sul are those of the Parana Flood Basalt Province, the same units which host the vast agate deposits. The Parana basin is the dominant geological element of southern

ANDREW DONNELLY PHOTO AURORA WEST SPECIMEN

ANDREW DONNELLY PHOTO/AURORA WEST SPECIMEN

Amethyst geodes from Rio Grande do Sul are found at most rock shows.

ANDREW DONNELLY PHOTO/AURORA WEST SPECIMEN

The rich shades of citrine geodes are achieved by heat treating amethyst geodes.

BRAD CROSS PHOTO

Tunnels are dug into the dense Sao Gabriel basalt flow in search of amethyst geodes.

Brazil and extends from São Paulo through Parana, Santa Catarina, and Rio Grande do Sul to Uruguay and Paraguay.

The 138 million- to 127 million-year-old Parana basalts erupted in an extremely arid desert environment that was dominated by sand dunes, as evidenced by the extensive red sandstones (the Botucatú Formation) found at the base of the volcanic sequence. There were also quiet periods during the various basalt floods in which layers of sand and sediment built up, separating the various flows. The fine-grained basalts that host the geodes are composed of the minerals plagioclase, pyroxene, magnetite, and a large amount of volcanic glass.

Up to nine individual basaltic flows are found within the geode-producing area. However, the amethyst geodes are only located in the fifth flow, named the São Gabriel Flow (the miners refer to this unit as "basalto portador"), in a well-defined horizon 1,300 to 1,450 feet above sea level. This geode-bearing flow can be subdivided into three specific units from the top to the base: a 15- to 30-foot-thick weathered vesicular basalt horizon often containing angular sandstone fragments, a 1- to 5-foot-thick transition zone of highly fractured basalt, and a 65- to 100-foot-thick massive basalt. This last can be further subdivided from top to bottom into a 10-foot-thick layer that contains the geodes, a 30- to 50-foot-thick massive basalt, and a 10- to 15-foot-thick highly fractured basal unit.

The amount and the quality of the amethyst from this basalt unit have turned this area into the main worldwide supplier of amethyst to the international market. Although production records are not kept, it has been estimated that approximately 100 to 200 tons of geodes per month and 20 to 30 tons of amethyst crystals for cutting per month are produced in the region.

The geodes from Rio Grande do Sul are usually elongated vertically in a chimney, cylindrical, or pipelike form, and most have a spherical cap toward the top. The base of the geode is generally dimpled, upwardly convex. The pointed, spherical, caplike shapes are always found aligned in an upward position in the basalt flow. Due to their unusual shape, some folks refer to these geodes as "cathedrals" and "amethyst tunnels."

The formation of these amethyst geodes followed a two-stage process that is very similar to other geodes throughout the world. The early magmatic stage is responsible for the generation of the cavity, with the second phase following millions of years later with a very low-temperature mineralization or cavity filling.

There is no question these are unusually shaped geodes. How does this shape form, and why are the geodes all aligned in a specific horizon within the upper part of the basalt flow at the same elevation throughout the region? Numerous studies have shown that this can be explained by the ascent of a fluid with a lower density and viscosity than the surrounding medium, as well as an increasing viscosity from the bottom of the flow to the surface.

Volatile constituents are dissolved in every magma. These are mainly carbon dioxide and water. When the magma rose through the fissures in southern Brazil, the solubility of the volatile components in the magma decreased. The volatiles were exsolved, and gas bubbles formed. Exsolving gas bubbles can coalesce quite easily in magma with low melt viscosities. Upon further ascent in the flow, fluid bodies can eventually split into smaller cap-shaped bodies of similar size, shapes exactly like we see in the Brazilian geodes. Once referred to as "spike amygdules," these Brazilian vesicles can be man size, and it's difficult to explain their size by the formation of gas bubbles from a basaltic magma alone. Some geologic models indicate that the hot lava reacts with cool water from rain, rivers, or underlying aquifers that may have circulated through the cooling lava flows.

The second step in the formation of amethyst geodes is the filling of the cavities. Several recent studies used potassium-argon isotopes to determine the age of the outside layer of celadonite, thus providing us with clues on the age of the geodes. They suggest that the final filling of the large amethyst geodes occurred some 40 million to 60 million years after the formation of the cavity. These same studies indicate that geode infill is a long-lasting process, on the order of millions of years. It has also been demonstrated that the fluids that were present during the filling of the amethyst geodes were very low temperature, less than 200 degrees F.

*continued on next page*

## Brazil's Amethyst Geodes *from page 29*

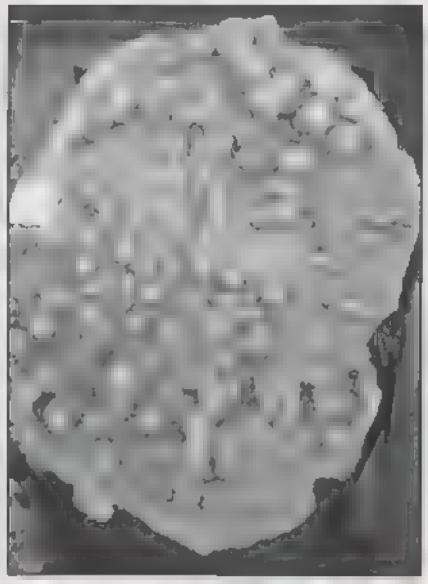
A good question to ask is, 'Where do the geode-forming fluids come from?' The late timing of the actual geode formation with respect to the formation of the cavity strongly suggests a meteoric source for the mineralizing solutions. However, it's important to remember the extensive red sandstone underlying the volcanic sequence. This sandstone is one of the world's largest freshwater reservoirs, the Guarani aquifer system. The water temperature of this artesian aquifer is somewhat comparable to the temperature of formation for the mineralizing solutions and should not be excluded as a possible source for the solution filling of the amethyst geodes.

Now that we have a fluid to infill the cavity, what is the source of silica to form the agate rim and internal amethyst crystals? The most likely silica source is the highly reactive interstitial glass in the host basalt. Additional components in the basalt are an excellent source for the calcite and other secondary minerals sometimes found in the geodes.

Without question, some of the world's largest and most beautiful geodes are found in these South American countries. History's greatest amethyst geode was discovered in 1900 in the Serra do Mar about 87 miles north of Santa Cruz in Rio Grande do Sul. The geode was far too large to remove intact, 32 feet long, 6 feet wide, and 3 feet high. It weighed about 35 tons. Ten sections weighing a total of 15 tons were shipped to Idar-Oberstein, Germany, reassembled, and shown in the Dusseldorf Exhibition of 1902 where deep-violet crystals averaging 1 inches in diameter caused a sensation. This region of Brazil has produced at least 100 times more amethyst than the next most prolific locality in the world. It is so abundant that almost every private collector and museum has at least one specimen.

Visiting Brazil's amethyst mines means an often arduous, though colorful, trip. I flew via São Paulo, Brazil, into Porto Alegre, the capital of the state of Rio Grande do Sul. The drive to Soledade was some three hours long, but cuts through some of the most beautiful country to be found anywhere. The landscape turns from coastal lowlands to a horizon dominated by subtropical forested hills. Watercourses wind through diverse vegetation, and the deep red soil hosts some of the most beautiful wooded areas one can ever imagine. Exotic ferns and fancy, colorful mushrooms abound, as do unique animals and wonderful birds.

Most amethyst geodes from the Ametista do Sul region display the following mineral sequence: a very thin dark-green exterior of fine-grained



ANDREW DONNELLY PHOTO AURORA WEST SPECIMEN

**Although it does not have the lavender color, the unusual crystal formations of this 6-foot-diameter specimen make it a real prize.**

celadonite which facilitates their extraction during mining; a less than 1-inch wide microcrystalline massive quartz or banded agate layer; a less than 1-inch-wide layer of incompletely crystallized and fractured colorless to milky quartz; and a layer of amethyst showing progressive color zoning, which continues from the last colorless quartz layer to the darker purple quartz. Within each individual crystal, bands of amethyst color alternate with colorless bands having light and dark patches. The color can also be modified to a fine orange color. These heat-treated amethyst geodes are often sold as citrine geodes.

Late-stage or secondary minerals are represented by calcite, scolecite and barite, which occur on top of the silica minerals. The youngest generation of calcite in the geodes displays a variety of crystal habits, from flat rhombohedra to elongated scalenohedra and long prismatic crystals. Some of the geodes contain calcite crystals, and occasionally quartz pseudomorphs after anhydrite crystals up to 6 inches long. The pseudomorphs are rectangular and taper to thin, flat tips.

Both Brazilian and Uruguayan amethyst geodes commonly contain inclusions of radiating crystal groups or tufts of long, thin crystals that range from needlelike to fibrous. Golden yellow goethite crystal groups stand out in relative high relief within the purple quartz. The long, yellowish goethite crystals outline an earlier stage of development of the amethyst crystal. This indicates that the goethite crystals were growing upon the faces of the amethyst crystal while it was developing, and it incorporated the goethite in the process.

Color zoning is also common in the Brazilian geodes. Zoning is observed as alternating shades of purple and colorless layers (zones) that are arranged concentrically parallel to the external crystal faces and are caused by successive stages of growth.

Oxygen isotope studies performed on agate, colorless quartz, and amethyst have not revealed any significant variations among the mineral phases analyzed. As a result, the silica mineral phases might have crystallized from an original fluid that was characterized by a constant temperature under stable geologic conditions.

The heaviest concentration of amethyst is within a 186-square-mile area of the Ametista do Sul region and includes as many as 500 mines or diggings (garimpos). The most active mining areas are found near the municipalities of Ametista do Sul, Planalto, Iraí, Frederico Westphalen, Alpestre, and Rodeio Bonito. Within these regions, it's not uncommon to find lichen-encrusted agate nodules and broken geodes with drusy quartz lying in the soil.

Local miners (garimpeiros) prospect for amethyst in open pits, as well as in underground tunnels or galleries, some up to 150 feet deep. The tunnels are driven parallel to each other into the cavity-rich basalt flow that has been exposed along the hillside. The miners drift (dig horizontally) with explosives, hydraulics, and a lot of very hard labor. The tunnels are usually interconnected, with many cross cuts. The mines seem like endless underground rooms with many big, arching pillars. The varying size and frequency of the amethyst pockets, as well as the quality and size of the individual amethyst crystals, is truly baffling. However, like at all other geode deposits, not all the specimens encountered are hollow. Many are simply solid quartz.

Miners drill holes in the dense basalt, pack them with black powder or other explosives, and slowly remove the host rock. Additional basalt is removed with a pneumatic hammer until the hammer suddenly lurches forward, indicating the point has broken into a hollow amethyst geode. The miners will now proceed carefully if they wish to remove the geode intact. Enough rock must now be chiseled away so that the miners can look through the small drill hole to inspect the quality of amethyst.

Inspection of the geode is accomplished by attaching a car battery to a small automotive lightbulb located at the end of a 3- to 4-foot electric wire. The cord and light bulb are slowly pushed through the half-inch drill hole into the geode to illuminate its sparkling interior.

Peeking inside the small wo.ad, the miner is the first to view one of the most spectacular sights ever imagined, an isolated void, sometimes the size of a small room, lined with intense and perfect purple crystals. With the interior lighted, the quality of the amethyst and the size of the geode is determined. If the amethyst is pale and of poor quality, the miners often continue to drill and blast without attempting to save it. If the amethyst is of high quality, the miner will laboriously chisel away, trying to remove the geode intact. This involves anywhere from several days up to a week of handwork with hammer and chisel—lots of muscle and lots of patience.

The Brazilian geodes' outer surfaces are heavily coated with dark-green micaceous minerals such as celadonite, and they break cleanly and fairly easily away from the encompassing basalt. Most geodes from Uruguay have little to no outer mineral coating, making them extremely difficult to separate when found encased in basalt.

Geodes that contain large quantities of gem-grade amethyst are often broken into sections and removed from the surrounding rock matrix as quickly as possible. They are then taken to a secure area where individual crystals will later be transformed into facet-grade rough. A pocket of gem-grade amethyst worth several thousand dollars can be an irresistible overnight temptation for a miner whose salary is only several hundred dollars per month.

The geodes are weighed in the field on crude scales and the miners are paid based upon the production and quality of the geode. The specimens are then taken to cutting factories in Soledade, Lajeado or Estrela, where they are either cut open with a diamond saw or tapped open with small, specially designed picks. The opened geodes are then either packed into 55-gallon drums or special crates. Sawdust is carefully packed around the geodes for shipment to worldwide destinations.

At the cutting centers, those geodes that have large crystals with good color and high clarity are often broken into plates. The plates are further broken down into individual crystals. These single crystals will soon become flawless facet-grade rough. This material sells by the gram, not the pound. Individual amethyst crystals are held between the fingers, and with a small hammer known as a swing hammer, the imperfections within the crystal are quickly and accurately cobbed away. Experience is the key to successfully cobbing amethyst. It is not at all uncommon to see a man in a Soledade or Lajeado cutting factory with 25 years experience in cobbing work a single crystal down to a pea size flawless stone within a matter of minutes. From here, cutters fashion the rough into a sparkling stone to be worn in a lovely ring, a bright pendant, or a brilliant brooch.

Like geodes from other sources, Brazilian geodes may be sawed open or they may be "scored" open, using small, pointed picks. The geodes are first marked down the middle with a chalk line so that two equal halves are defined. The miners gently tap the pick along the chalk line to score the geodes. As small fractures develop perpendicular to the scored line, an epoxy type glue is used to penetrate and seal the fracture and keep the geode from splitting into numerous plates. The chalk line is carefully followed until the entire circumference is deeply scored. The geode is then carefully pried apart with a large flat head screwdriver, revealing the rich inner beauty.

Cutting geodes usually requires using a 36-inch diamond lapidary saw. Once the geode is cut down the middle, the specimen is sanded and polished by hand. The smaller beauties are taken to large, horizontal belt sanders, where the freshly cut surfaces are sanded on 220- and 600-grit sanding cloths. They are given a final polish with a hard felt wheel and cerium oxide. The larger geodes that cannot be easily handled are treated using hand-held sanding and polishing equipment.

It's not at all unusual to find citrine geodes on today's market. Unless you are told otherwise, you can safely assume that it is heat treated amethyst.

BRAD L. CROSS PHOTO

**Some Brazilian geodes are split open with small picks and hammers to give them a "natural" appearance, unlike cut and polished geodes.**

The question of color in crystallized quartz is a fascinating one, the lovely colors being related to the internal atomic structure and its imperfections. Citrine and amethyst also owe their color in part to background radiation. The radiation primarily occurs due to naturally occurring potassium-40 and members of the uranium and thorium decay series found in rocks and soil. As is true for amethyst, the formation of citrine requires the presence of trace amounts of iron impurities in the quartz. The difference between citrine and amethyst is the oxidation state of the iron: Fe+3 in citrine and Fe+4 in amethyst.

Subjecting amethyst to heat will reduce the oxidation state of the iron impurities in the quartz structure, thereby causing amethyst's purple color to fade to yellow, reddish-orange, green, or colorless, depending on the amount and duration of the heat applied. The purple color usually can be regained by irradiation, which re-oxidizes the iron impurities.

Nature produces the same shades of amethyst and citrine that heat enhancement creates, and in a finished stone, it can be difficult to determine whether the color is natural or heat-induced. One telltale sign is that inclusions may expand under controlled heat, causing minute fractures in the stone.

While at the cutting factories in Brazil, I found various-size kilns, like the furnaces used by a ceramics worker, for heating the amethyst to citrine. Some of the kilns were small and were used for treating facet-grade amethyst. Others were large and could hold a nice size geode. The thermostats on these ovens were adjusted to bring the stone slowly up to the desired temperature, then return the temperature slowly back to normal.

The results were astonishing, all dependent upon the amount and duration of heating. Some very dark amethyst was simply reduced to a lighter shade, while the very light amethyst was heated to produce citrine and, to a lesser extent, green quartz. If the amethyst contained color zoning, even more dramatic color changes were observed. Because the results of heat treatment on these geodes are considered stable and permanent under most conditions, no special care is needed.

On rare occasion, opening an amethyst geode reveals some formational wonders that are an added bonus. Some of the most striking specimens are the amethyst "stalactite" sections that frequently have a core of concentrically

*continued on next page*

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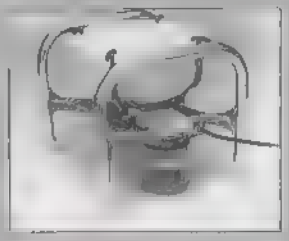

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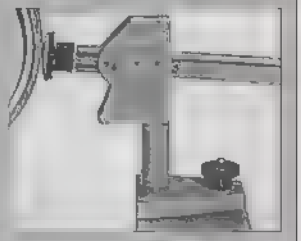

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## Brazil's Geodes *from page 31*

banded agate, calcite or quartz with a 360-degree rim of amethyst crystals. These amethyst stalactites are formed when amethyst crystals grow as a coating over agate or calcite tubes that have grown inside the geode during formation. Many of the damaged or lightly colored stalactites, not suitable for specimen display, are sliced some 3 millimeters to 4 millimeters thick, are polished on both sides, and are used for exquisite jewelry. The variety of size and color combinations is amazing, each yielding sections that are different from those cut from any other stalactite. The vast majority of these pieces come from Uruguay.

High-quality amethyst stalactites are rare. Only one in 10 is free from damage, and of these, only one in 10 will have good color. Only one in 10 of these select few are lustrous and shiny. Therfore, only about one in 1,000 is a mineral collector's fantasy. Sometimes, the specimens are no more than little bulbs, knobs or nubs of amethyst, and some even have a hollow, pointed cavity where a scalenohedral calcite crystal once existed. It's also not uncommon to find hollow hexagonal columns of drusy amethyst crystals with flat tops. Some casts still have the calcite in them.

What article on South American geodes would be complete without mention of amethyst flowers? These little treasures are primarily found in the Getúlio Vargas region of Rio Grande do Sul and are classic flowerlike formations of radiating medium- to light-purple amethyst crystals arranged in a somewhat circular pattern. At times, there will be multiple "blooms" closely resembling clusters of flowers. These are literally the "flowers of the mineral kingdom." What an incredible mineralogical world!

The price per pound of the geodes depends on a number of factors, including the color, clarity and brilliance of the crystals. Darker color usually means a higher price per pound. The thicker the wall, however, the less cost per pound. Is the geode cut and polished? Polishing the geode will usually increase the price per pound.

As you can see, we've come a long way in our understanding of these huge geodes since their initial discovery in the 1800s. But who could not help but be envious of those very first European immigrants who discovered these sparkling beauties? ✧

*Brad Cross is author of* The Agates of Northern Mexico *and* Gem Trails of Texas. *A new book,* Geodes: Nature's Treasures, *coauthored with June Culp Zeitner, will be available soon.*

GOLD AND GEM HIGHWAYS

# ROADSIDE PANNING SITES IN CALIFORNIA

## Part VI: Riverside, Sacramento, and San Benito Counties

Story and Maps
by David and Clois Walker

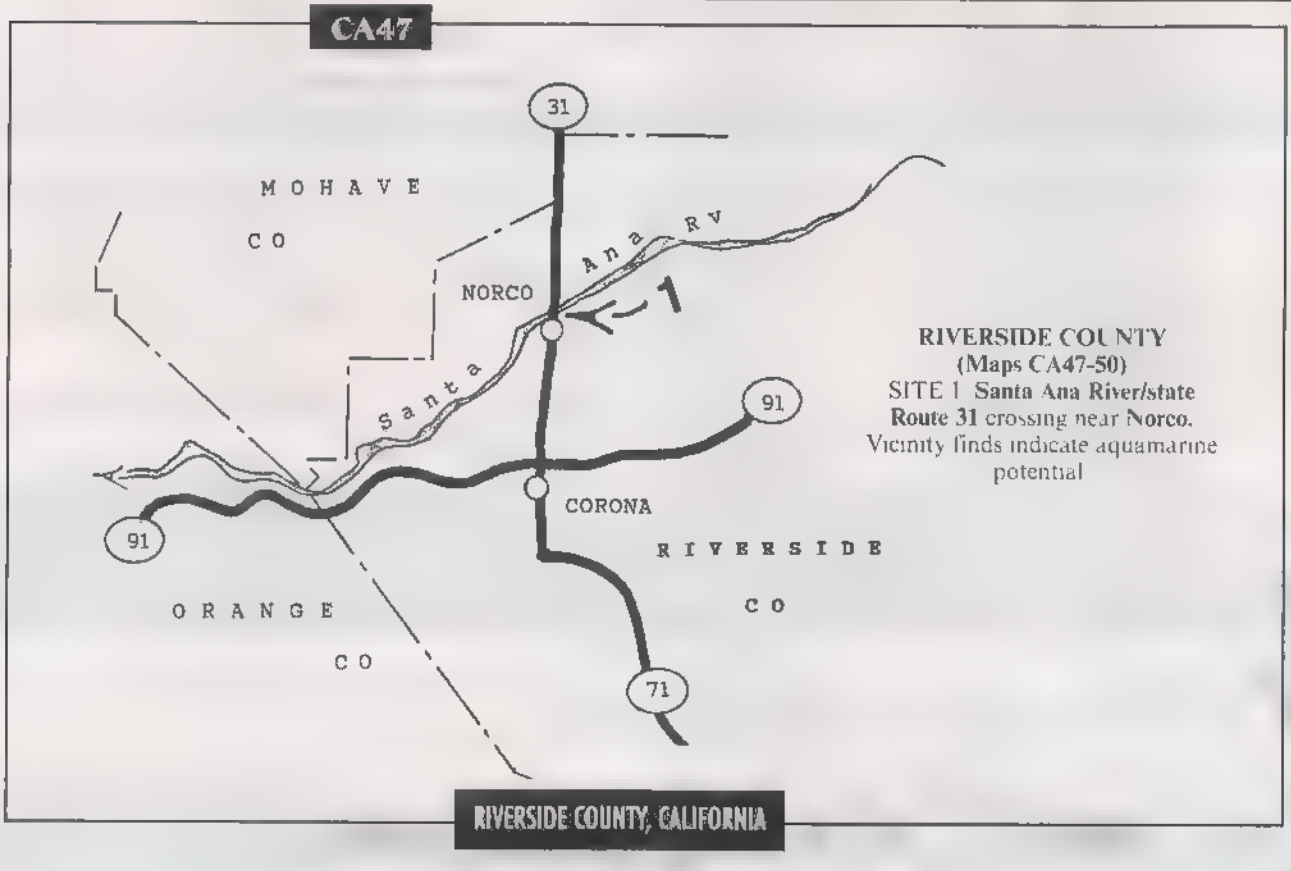
This is the sixth in a series of 10 articles containing county-by-county maps of suggested panning and screening sites at highway/stream crossings where appreciable finds have been previously reported on upstream watersheds. The principles of erosion make it likely that minerals and gemstones have been deposited in river gravels, awaiting removal by a rockhound with a pan.

Obviously, a highway-convenience study of this kind is most advantageous for seniors and others who prefer panning under a nice, shaded bridge crossing to tramping over hill and dale. It also eliminates the necessity of locating and getting permission from property owners.

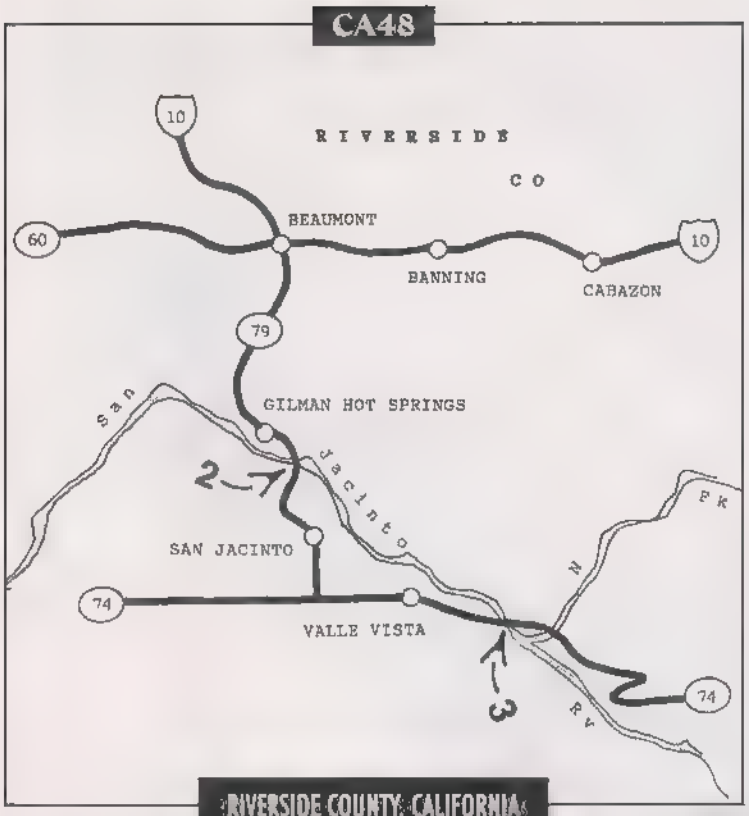
Don't forget, however, that the government to which these rights of way belong has some regulations of its own. Be sure to observe the usual safety and environmental standards if you want to collect without a hassle.

The maps provided contain the most up-to-date information available to us, but it is advisable to consult a current state highway map when planning an outing, for overall orientation in the field and because highway designations have been known to change.

So good luck! While we can't guarantee you'll hit the jackpot, we can almost assure an enjoyable outing.

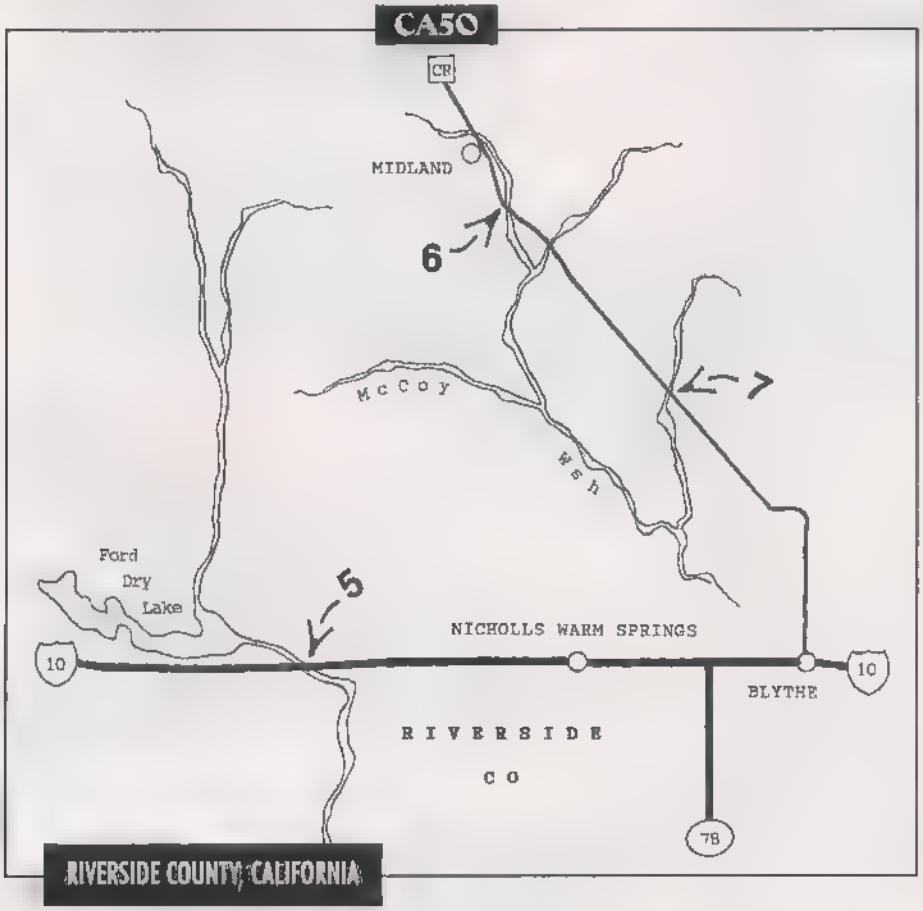



**RIVERSIDE COUNTY**
**(Maps CA47-50)**
SITE 1 **Santa Ana River/state Route 31** crossing near **Norco.**
Vicinity finds indicate aquamarine potential



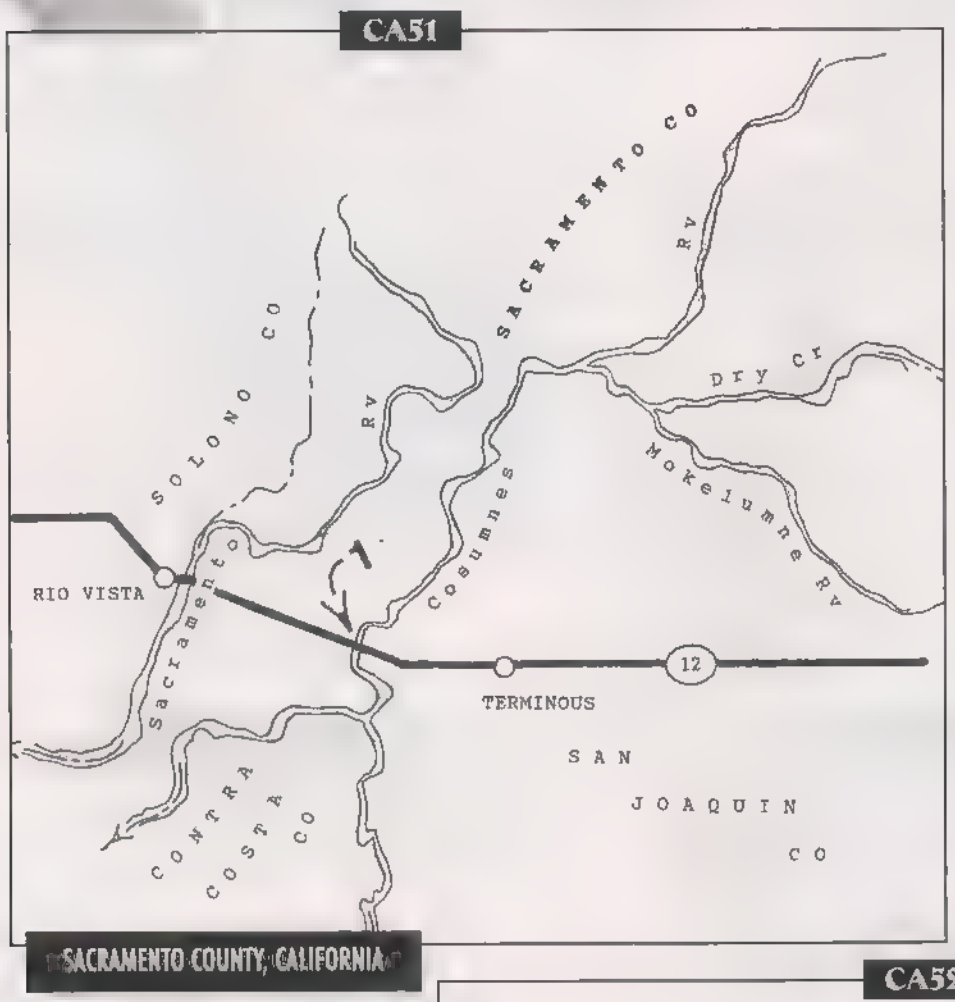

SITE 2 **San Jacinto River/state Route 79** crossing, near **San Jacinto.** Vicinity finds include amethyst, quartz crystals, and tourmaline.
SITE 3 **Jacinto River/state Route 74** crossing, near **Valle Vista.** Vicinity finds include amazonstone, quartz crystals, and tourmaline.

SITE 4 **Wilson Creek/County Road** crossing, near **Aguanga.** Vicinity finds include amazonstone, quartz crystals, and tourmaline.

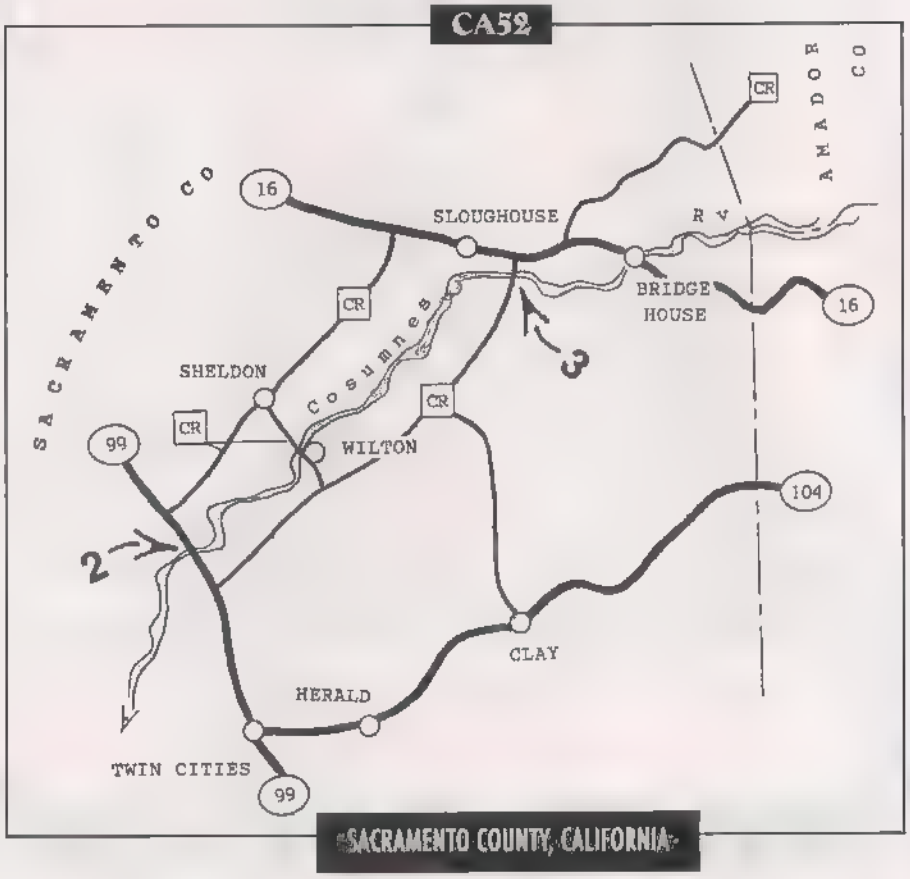



SITE 5 **Tributary Ford Dry Lake/ Interstate 10** crossing, near **Nicholls Warm Springs.** Vicinity finds include agate and chalcedony.
SITE 6 **Tributary McCoy Wash/ County Road** crossing near **Blythe.** Vicinity finds indicate spinel potential.
SITE 7 **Tributary McCoy Wash/ County Road** crossing, near **Blythe.** Vicinity finds indicate spinel potential.

*continued on next page*




**SACRAMENTO COUNTY**
**(Maps CA51-53)**
SITE 1. **Cosumnes River/state Route 12** crossing near **Terminous.** Vicinity finds indicate gold potential.




SITE 2. **Cosumnes River/state Route 99** crossing, near **Twin Cities.** Vicinity finds indicate gold potential
SITE 3. **Cosumnes River/County Road** crossing, near **Sloughouse.** Vicinity finds indicate gold potential

*continued on page 38*

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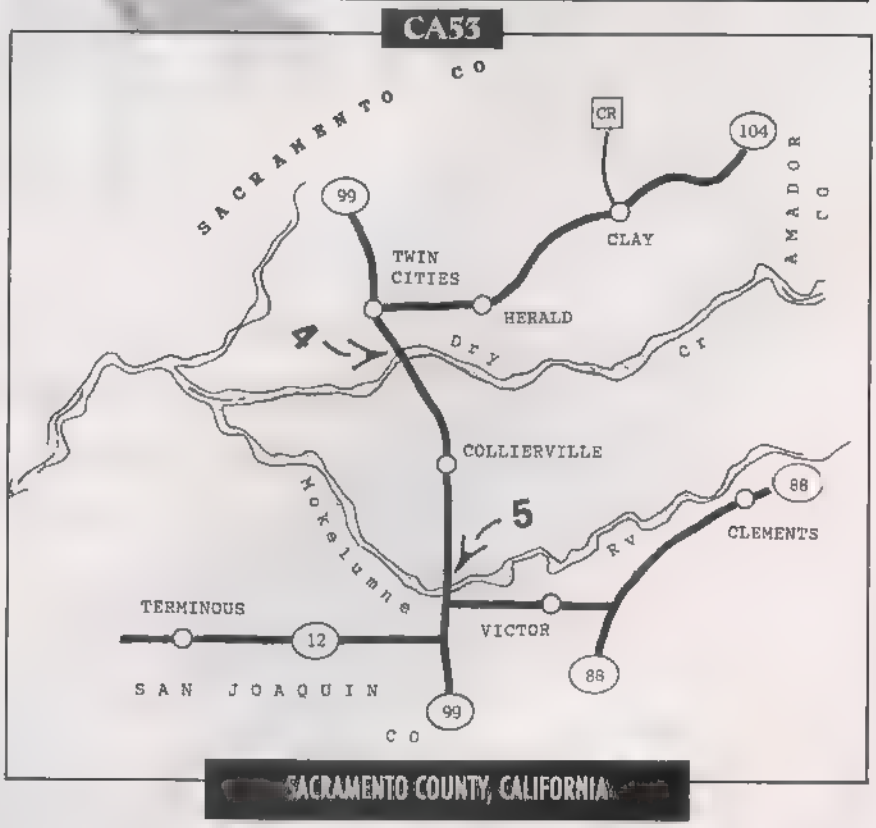
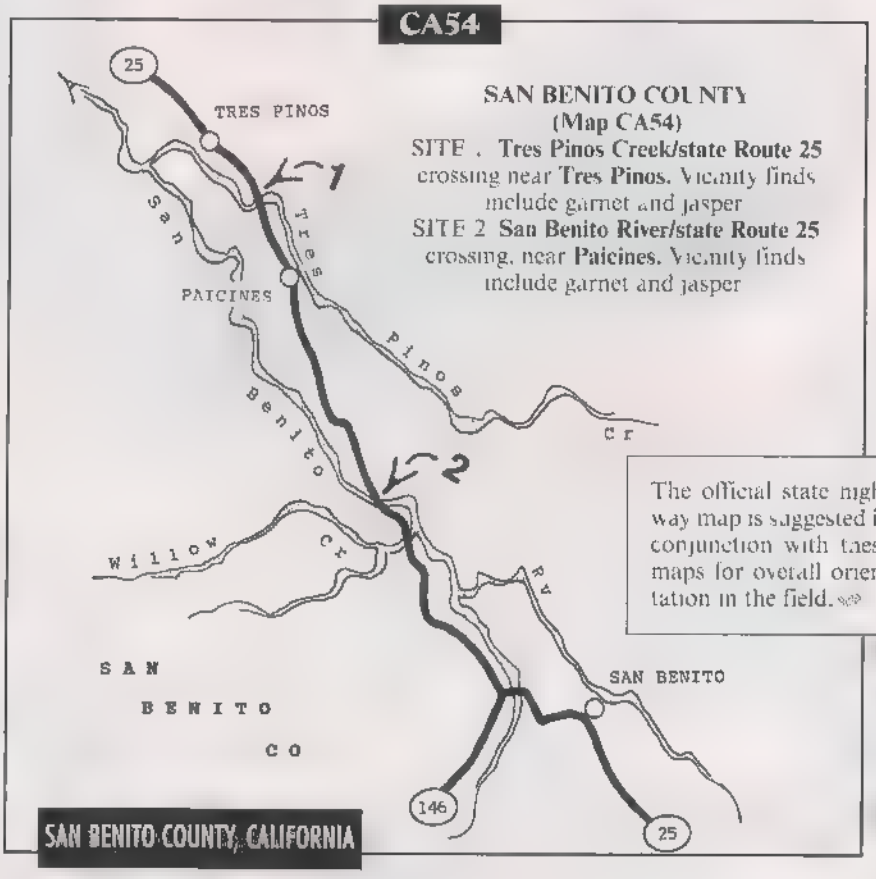
## Roadside Panning Sites in California *from page 36*



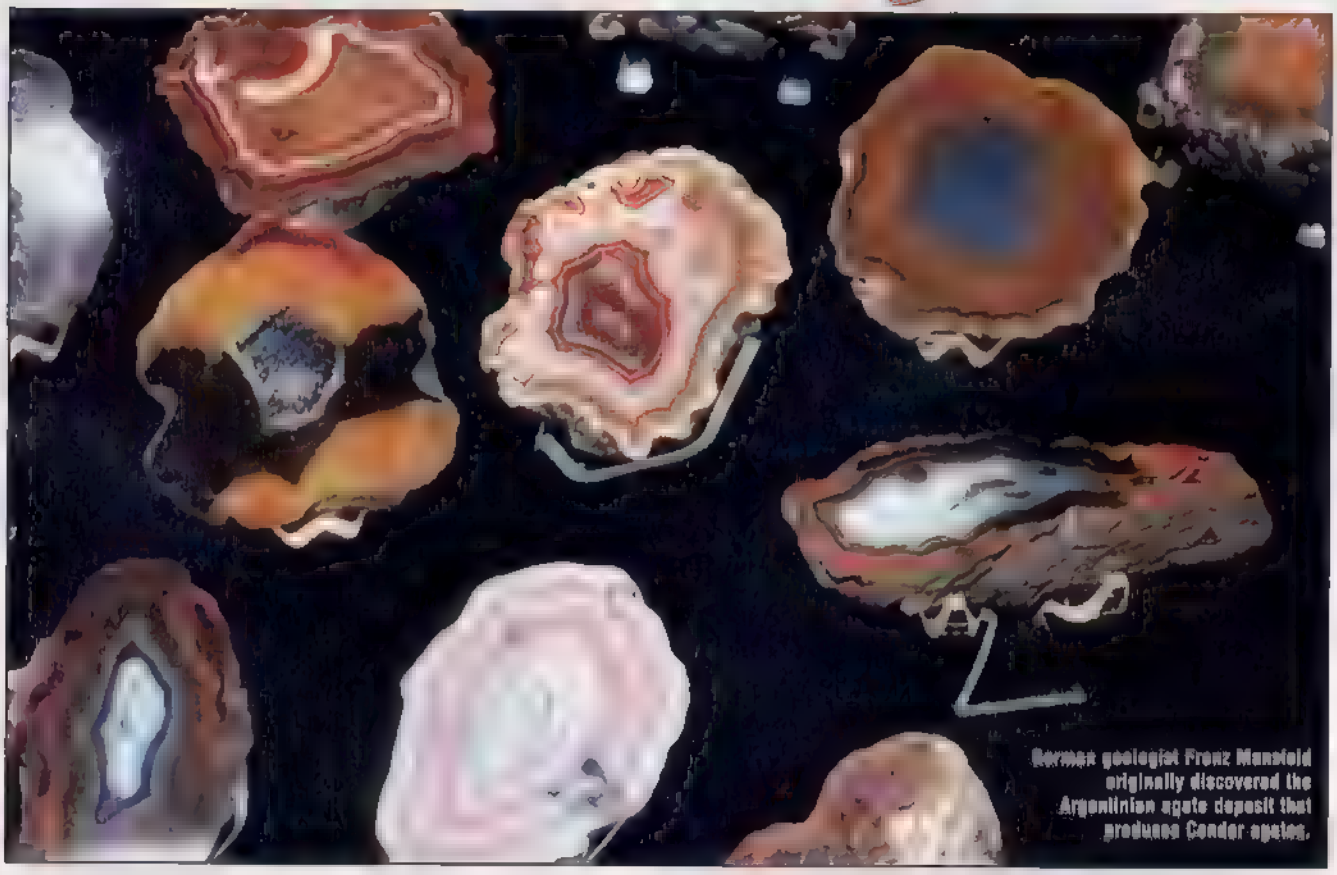

SITE 4 **Dry Creek/state Route 99** crossing, near **Collierville.** Vicinity finds indicate gold potential
SITE 5 **Mokelumne River/state Route 99** crossing, near **Victor.** Vicinity finds indicate gold potential.




**SAN BENITO COUNTY**
**(Map CA54)**
SITE 1 **Tres Pinos Creek/state Route 25** crossing near **Tres Pinos.** Vicinity finds include garnet and jasper
SITE 2 **San Benito River/state Route 25** crossing, near **Paicines.** Vicinity finds include garnet and jasper

The official state highway map is suggested in conjunction with these maps for overall orientation in the field.

# Argentina's Condor Agates


German geologist Franz Mansfeld originally discovered the Argentinian agate deposit that produces Condor agates.

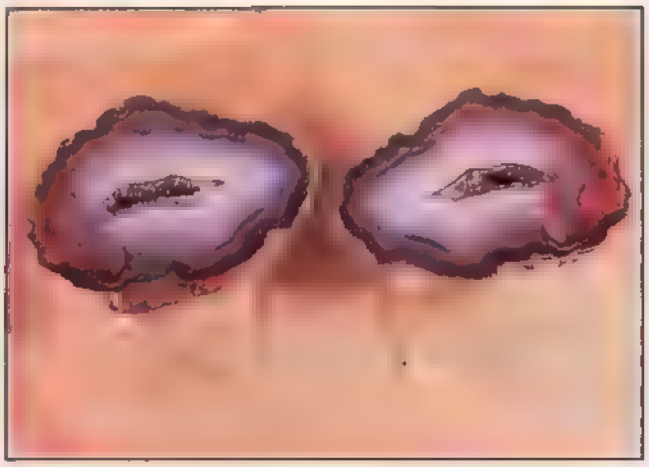
## Their Colors and Patterns Are Unrivaled

Story and Photos by Bob Jones

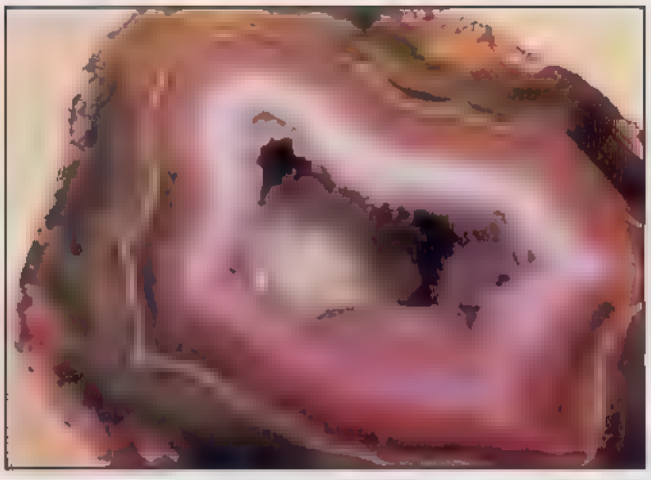
Agate ranks among the earliest gemstones humans found attractive. Their multicolored banding and internal features clearly made them special. This is why the leadership of the 2005 Mineralientage München event, the famous European gem and mineral show held in Munich each October has chosen agate as its theme mineral. Following a tradition, this great show has invited some of the world's great agates to be on display.

Few sources of fine agate rival the historically important agate deposit on Germany's Nahe River. The impact that deposit has had on the growth and development of the gem industry, centered in the towns of Idar and Oberstein, is profound.

Beginning in the Middle Ages, these companion cities emerged as the world's leading source of fine agate and gem art. There is some evidence the industry has its roots in Roman times. Even today, Idar-Oberstein is a world leader in the production of superb gem art creations, a position based on the discovery of agates in the ancient volcanics of the area.



What is the explanation for the abrupt color change in this Condor agate?



Crystallized calcite formed in the interior of this Condor agate during the final stages of its development.

The odd, bright-yellow spots around the perimeter of this fortification agate seem to have invaded the banding via outside forces.

As the ancient agate deposits along the Nahe River were slowly depleted, local agate artisans began searching the world for fresh supplies. Thus in 1827, craftsmen from Idar discovered the great agate deposits in Uruguay and Brazil. Some agates from these deposits will be displayed at the 2005 show.

Remarkably, in the 20th century, German geologist Franz Mansfeld was responsible for finding yet another great South American agate deposit, this time in Argentina. It is entirely appropriate that the superb agates from his great discovery be a major feature of this year's show.

Joining the Argentina agates will be individual and small collections of agates that represent other great agate deposits. Best known of the individual scenic agates invited to the show is the one chosen as the "theme agate," the famous "Hooded Owl" scenic agate originally found by an Indian boy near Sueco, Chihuahua, Mexico. It takes no imagination at all to see the sharply outlined image of an owl created by bright carnelian red with a purple-red agate background. Now owned by Brad Cross of Texas, the Hooded Owl agate will be just one important highlight of what we might call an "agate fest" in Munich in October.

Representing the agates from Argentina is a unique exhibit of paired agate halves owned by David Wilber, a noted gem and mineral connoisseur. This unique agate collection represents the best from an area currently producing agates that rival stones from the older, better known agate regions of the world.

The aforementioned Argentinan agate deposit was lost and then re-discovered in 1992 through the work of one man, Luis de Los Santos. When Luis heard of the earlier discovery and its subsequent loss, he determined to follow in the German geologist's footsteps in hopes of discovering what could be a potentially important agate find!

It's been over 10 years since *Rock & Gem* published the first article on the discovery of these superb, colorful Argentina agates, which rival some of the best from Northern Mexico, Central Australia, South Dakota, Idar-Oberstein, and other famous sources. These agates, which Luis calls Condor agates, exhibit choice vibrantly colorful banded fortifications and patterns for which agates have become very well known. These beauties have made agates immensely popular once again. The rich colors and classic fortification banding of Condor agates are pleasing to the eye and exciting to the lapidary. While other agate sources have slowly diminished in production, Condor agates have burst on the scene in sufficient quantity to satisfy even the most ardent agate lover!

The discovery of Condor agates is a story to rival a fairy tale. Finding and harvesting these agates has been arduous, to say the least. The remote location and severe weather, even during the Southern Hemisphere's summer, have been a challenge to overcome in the search for this banded treasure.

Initially, the agates were found scattered loose over the landscape and were readily harvested in quantity. Today, surface collecting is no longer prolific, so these fine agates are collected from shallow diggings in the frozen agate field in Patagonia.

Luis' search for and discovery of these agates required luck, persistence, patience, and determination. It can be said that he followed a dream, a rumor, and a cold trail to achieve success.

Argentina-born Luis' interest in minerals reaches back into his childhood when he collected odd and attractive pebbles. Like so many youngsters, Luis was not able to keep his random collection, but his love of minerals lingered.

When Luis grew up, he studied acting and worked in construction. As he handled the wood used in construction, he found the grainy patterns in some wood very appealing, and he began to collect wooden objects, in particular wooden eggs. Then he saw an egg carved from Argentina's famous banded red Catamarca rhodochrosite. This renewed his interest in rocks and minerals, especially rhodochrosite, with its varied and attractive patterns and colors.

It was while pursuing that lovely mineral that he met an old German prospector who showed him a petrified pine cone and pieces of petrified wood he had collected. Sensing an opportunity, Luis found out more about these strange fossils and began to collect them in hopes of selling them.

Once he had collected a quantity of the pine cones, he brought a small load of them to the Denver Show in 1989. Though he could not speak English, he sold his pine cone cache immediately. He quickly returned to Argentina and began collecting pine cones and other fossils in earnest. He had suddenly become a full-fledged dealer in the hobby.

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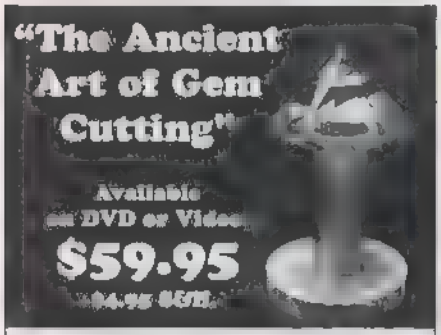
Attention: Collectors, cutters, and connoisseurs of fine gems.

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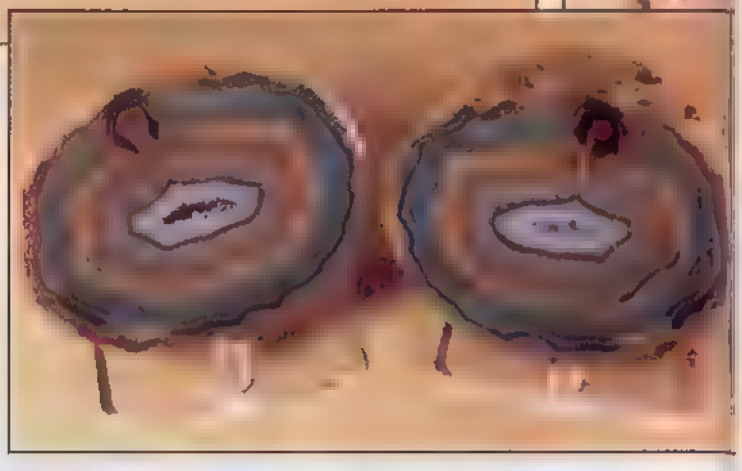
## Argentina's Condor Agates *from page 41*

This is a typical Condor agate, with nice fortification banding, excellent color, and a euhedral quartz center.



The escape tube in this Condor agate almost made it to the rim of the agate

On one of Luis's visits to Catamarca, he happened to talk with an old friend of Dr. Franz Mansfeld, a German geologist noted for his contributions to the literature on the Catamarca rhodochrosite deposit. This friend told Luis of an agate field that Mansfeld had found deep in the Patagonia region. The area was reported to be rich in colorful agates. Luis realized that finding the now-lost agate field would be both exciting and fruitful, so he made repeated visits to the Patagonia region, asking questions of the locals in hopes he might obtain information about Dr. Mansfeld's travels, the routes he followed and the areas he explored.

On one of his trips, he saw a broken piece of a banded agate being used as a doorstop in a small hut in a remote area. He knew he was close to his goal. By talking to the local ranchers, he finally tracked down the deposit, a broad area of low hills where agates were scattered over the surface of several rhyolite and andesite outcrops. Such rock formations are typical sources of agate.

Realizing he had made an important find, Luis collected what he could and brought this initial load to the United States. It sold instantly, and he immediately returned to collect again. Since the region is so remote, the agates have to be hand collected and packed out for miles on horseback. Early on, Luis realized not all the agates were choice and colorful; many were severely damaged from natural causes. So he carefully examined each agate, setting up a selection process right on site. This was far more productive, as he bagged the better agates and left the less attractive agates in place. Horses transported the agates to a road, where they could be loaded on a truck for trans-shipment to Buenos Aires, where Luis lived. From there, he could ship his product to the United States.

Luis soon realized he could do better in the agate business if he cut and polished his finds. So he moved to America and learned the necessary techniques, all the while going to more and more shows to sell what he now was calling Condor agates, after the native birds that were abundant in the agate region.

As indicated, agate collecting in Patagonia is no easy task. The weather is horrible most of the time, very cold and windy. The ground is always frozen, as it often snows there in the summer. It is necessary to reach the agate fields by horseback and to bring in enough supplies to set up camp and stay for a month or longer at a time.

Condor agates are noted for their intense color and distinct banding.

Only in this way could extensive exploration of the agate fields be accomplished. Buyers should keep this in mind when they decide to purchase examples of these choice agates.

In the early days of Condor agate collecting, a typical month of effort would yield anywhere from 1 ton to 3 tons of good agates. Currently, excavation is required to find the agates, so an extra effort is needed to supply the ever-growing demand for these superb gems.

Condor agates came to take their place among the most attractive and popular agates of the world. I doubt Luis realized at the time of his discovery that the fruits of his search would become a featured exhibit at the famous Tucson Gem & Mineral Show, and now the equally famous Mineralientage Munchen, 2005. The highlight of each show is an amazing Condor agate exhibit put together by David Wilber. Working in cooperation with Luis, David has assembled an amazing Condor agate collection of matched pairs of nodules and geodes that represent the best from the Patagonia agate fields.

David began his collecting as a youngster. His first love was fine mineral crystals. Through the years, David built a strong international reputation by assembling one of the major mineral collections of the last half the 20th century. Exhibited at all the major shows for years, the Wilber collection was both admired and envied. Specimens from the collection have been featured in mineral magazines and books over the last several decades, and many are now important display specimens in major museums.

Though David emerged as a top mineral specimen collector, he was also quietly attracted to the finer examples of

*continued on next page*

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## Argentina's Condor Agates *from page 43*

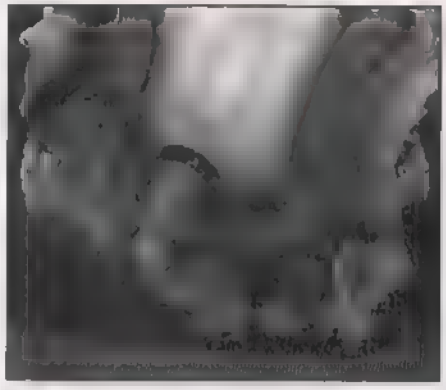
lapidary materials, in particular agate His first effort in agate collecting produced a major collection of Mexican agates, which he eventually sold Having honed his skills in judging fine agates, when he saw the Condor agates, he was instantly attracted to them

What is remarkable about David is the sixth sense he has about collecting Each time he has developed an outstanding collection, whether it be minerals, agates, antiques, or anything else, he has foreseen the potential of the collectible He is a true visionary who anticipates when a collectible will become more popular and its values will be positively impacted He has successfully applied his vision several times, primarily to minerals For decades, whenever David gave a talk about minerals, he predicted there would be an immense rise in the popularity of fine minerals and their values would reflect this. His prediction has certainly proved true David feels now is the time to collect Condor agates, for he perceives them as a good investment

It was inevitable that this skilled collector with vision saw the potential of what Luis had brought forth from Patagonia. When David saw the beauty of what Luis was collecting, he realized that assembling a fine collection of Condor agates would be both appealing and a good investment Starting slowly, he began to buy some of the better pieces that Luis offered for sale. This continued for a couple of years, as he gradually learned more about the agates from Argentina Then about three years ago, he decided to get really serious about building a fine collection of Condor agates Just as when he collected fine minerals, he wanted only the best that Luis could collect This determination has culminated in the agate collection seen at Tucson and now in Munich

To develop such a magnificent collection, David made an agreement with Luis Any time Luis found an especially fine agate, he would offer it to David, who would try to add it to his growing collection The result of this collaboration is represented by the amazing collection of matching halves of Condor agate nodules dug by Luis and displayed by David

What makes Condor agates so appealing is their superb fortification patterns, seen only in the finest agates This, coupled with the vibrant colors in these fortification bands, makes them the equal of the best of the older noted localities These special characteristics, coupled with the quantity of the specimens brought forth, will keep the interest level of collectors and lapidaries very high for years to come



This Condor agate shows an unusual escape tube that managed to force its way between the fortification bands.

If you compare Condor agates with those from Northern Mexico, you'll note there are distinct differences between them While a small number of Condor agates show oddities like sagenite, tubes, eyes, moss, and top banding, these features are decidedly in the minority in Condor agates Mexican agates, on the other hand, seem to be replete with such features When Condor agates are placed side by side with fine Mexican agates, it is obvious that the colors of Condor agate outshine those of the Mexican agates, because the colors are primary and more intense Most agates from Mexico and other sources tend to shade into pastel colors You'll notice that the red, orange, blue, and yellow in Condor agates seem richly vibrant, strong and intense Dramatic and abrupt color changes within banding are often seen in Condor agates.

Inevitably, when anyone looks at agates, the question of how they form comes to mind The answer to that question is still being sought by scientists Theories have been developed, some discarded, others enlarged upon The leading theory suggests that agates form in open gas pockets in rhyolite or andesite lava as the rock hardens, trapping gases within It is postulated that later, silica-rich solutions infused themselves into these openings slowly creating the banding so important to a good agate This action is thought to be tied to seasonal, sequential infusions of the silica-rich solutions which may be related to seasonal climate changes or sporadic surges of hot solutions from nearby hot springs, a common feature of active volcanic areas

A completely different theory was proposed by Ben Schaub, who postulated that as siliceous lava moves, small

blobs of included silica slowly gather together to form larger, rounded masses. As the enclosing rhyolite or andesite cools, these silica gel blobs gradually form banding by sequential cooling within the mass.

Other studies suggest that banding forms when silica gel slowly enters open cavities and interacts and reacts with mineral impurities also contained in the solutions. As the impurities are expelled from the silica gel, they form a lining around the inner surface of the gas cavity opening. As cooling continues, other impurities may form thin boundaries. As this action repeats, the result is the development of banding within the silica gel. The source of the silica gel is devitrification (surface water dissolving silica into solution) of the overlying high-silica volcanic rocks. As weathering releases silica into the ambient solutions, it is carried by these surface waters into the rock formation and its open gas cavities, bringing with it the dissolved silica and mineral impurities. As more silica gel invades the cavities in sequence, band after band forms, each a little different, as each band contains its own metallic impurities, which may impart a distinctive color to any given band.

In most cases, this process of banding continues until the cavity is full, the silica gel solution is no longer saturated, or the source dries up. At that point visible quartz crystals begin to form, lining any remaining open space with bright quartz points. This accounts for the small crystal-lined pockets commonly seen in Condor and other agates.

Sometimes, the color in one or more adjoining bands shows a sudden and very dramatic change in color. A band of red, for example, may abruptly erupt into a lively canary yellow. This abrupt color change is called chromography, and is most likely due to a sudden change in solution conditions within the agate. Also, a particular chromophore (a chemical that causes a color) may suddenly diminish in amount, and a second color, originally masked by the first chromophore, suddenly becomes visible. Another possibility is a sudden change in the chemistry of the invading solution, either in mineral content or in Ph factor.

It is important to keep in mind that as minerals in solution slowly solidify, heat is released. In a closed environment like an agate, this heat builds rapidly, as it can not easily escape. Since the silica gel banding may still be in a plastic-like state, it can be dramatically affected by this trapped heat. The gel swells, seeking a way to release pressure. It moves inevitably toward any point of weakness in the agate shell. This moving pressure distorts the banding, often forming what we call escape tubes as the hot interior moves toward, and sometimes escapes through, those points of weakness. This action drags and distorts the banding around the escaping hot core material. The agate banding develops undulations and curves as the bands are dragged and sometimes elongated, creating a teardrop design. This adds to the agate's attractive internal patterns. The teardrop shape always has the thicker end toward the center of the agate while the tapered end points toward the area of weakness. In rare cases, such material actually breaks through and escapes. This has created confusion about how agates form.

Early on, when agates were cut open and distortions were observed, it was thought that these teardrop shapes were evidence of channels along which the silica had entered the cavity to form the banding, so they were called access channels or invasive channels.

However, anyone observing an abundance of agates from all over the world, including Condor agates from Patagonia, sees instance after instance in which the distortions never reached the outer skin of the agate. This is visual proof that the band-forming material did not enter the agate through that channel, but rather that internal strife worked from the inside out. Therefore, these are escape tubes due to an internal function and are not formed from any outside influence. The distortion in the bandings surrounding the escape tube is additional proof of how such features form from internal pressures, not by invasive action.

In comparing Condor agates with those from other sources, the lack of abundant odd internal features like sagenite and tubes helps distinguish them. The intense color seen in Condor agates seems to exceed that of most other agates. Certainly, the main difference between Condor agates and those from earlier finds is simple. Condor agates are still pouring forth from Argentina in abundance, while other sources are largely depleted.

So enjoy what you see in these bright, colorful, banded agates and remember the effort of Luis de Los Santos in re-discovering of Dr. Mansfeld's Argentinian agate fields, his efforts to retrieve them, and the artistic ability of David Wilber to assemble one of the finer agate collections to be seen today.

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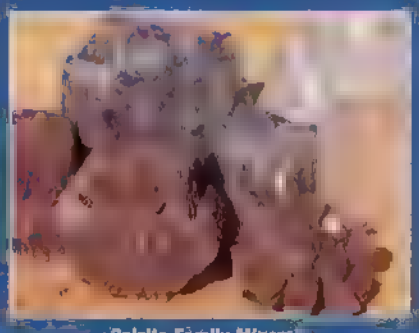


# KIDS

by Steve Baker

## Rock & Gem Kids Quiz

## Setting Tumbled Stones

We have discussed how to select stones to be polished in a rock tumbler (May 2005 Rock & Gem Kids), and the process of smoothing and polishing them. Now it is time to make jewelry with those pretty gems.

The most common way of setting tumbled stones is by gluing bell caps on them and attaching them to a bracelet or hanging them from a chain as a pendant. Bell caps are manufactured settings available at jewelry supply houses, that are glued to tumbled or "baroque" stones.

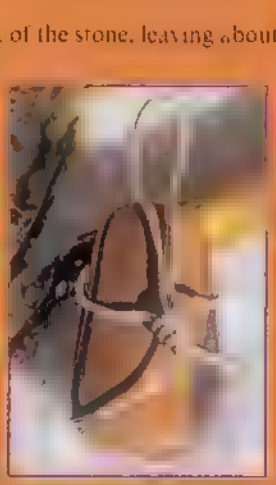
Bell caps are a simple method of making jewelry, but the glue will eventually let go and the stone will fall out of the setting and be lost. If you can find the stone, it can be glued back in place, but jewelry made with bell caps will generally not be durable.

A better method of setting irregularly shaped gems is called wire wrapping. With this method, 20 gauge to 24 gauge silver or copper wire is looped around the stone and twisted to make a setting that can be attached to jewelry. There are many ways to twist the wire, some of which are very complicated and beautiful. I will show you a simple wire wrapping method that can hold your tumbled stones or crystals securely without covering the beauty of the gem.

Silver wire is inexpensive and you can buy a couple feet for less than a dollar. You can use solid copper wire from old broken electrical devices to practice your wire wrapping skills. You can use small pieces of wire you trim from your project to make "jump rings" (small, unsoldered rings about ½ inch in diameter) with which to attach the wrapped gem to a necklace or bracelet.

The first step in wrapping a stone is to determine how you would like it to hang when worn. Take into account how it will look and how it can be supported by the two loops of wire we will wrap around it.

Next, orient the stone with the top pointing up, and hold the tail end of the wire at the back of the stone, leaving about a half inch of wire free. Wrap a loop of wire around the top, across the back and around the lower front of the stone in a "figure-eight" pattern.



Finally, bring a loop up the back of the stone to a point just above the top, and back down to your starting point, leaving about a half-inch extra for finishing. This loop will form the bail that will attach to your jewelry.

Gently remove the stone from the loose loops of wire. Hold the empty wire wrap form in your hand and carefully coil the free ends of your wire around the intersection of the loops and bail to make the whole assembly stay together.

Put your stone back into the loops, and position it so it will be held securely. Use any projections or indentations to make a secure fit.

To tighten the wire and finish the piece, use round-tipped needle-nose pliers to twist an S-shaped bend in both loops to make them snug. The round-nose pliers will not kink the wire. Kinking would greatly reduce the strength and durability of your jewelry.

For those whose wire wrapping skills need some time to develop, Don Norris invented Rock Wraps. They are basically pre-made wire wrap settings in various sizes that can be bent around your stone and then tightened with round-nose pliers. Individual Rock Wraps can be purchased online at http://rockwraps.homestead.com/Price.html for $4 to $6.

# LAPIDARY LORE AND MORE

by June Culp Zeitner

## Real de Catorce: Then and Now

In the mid-1970s, some of our Operation Rockhound groups joined Albert and me on a special side trip, which had been recommended by Mexican friends. At that time, few Americans knew about the Hidden City of Real de Catorce.

Real de Catorce was a booming city of nearly 50,000 people 200 years ago. A silver-mining city, it was so remote and difficult to get to that the city leaders got permission to mint their own silver coins and send the coins once a month to the capital under light guard. Known as the "city of 14 to watch for," no one ever knew whether it was 14 leaders or 14 vandals and thieves.

To escape the dangerous, roadless, ragged mountains, it was decided to dig a tunnel. Citizens of Real de Catorce would start at their end and road workers from Mexico City would start nearer the central mountains. A funny thing happened on the way to Real de Catorce – the tunnel didn't meet in the middle.

Digging all the hard dirt and carrying it out by pails full resulted in a narrow tunnel with a rough floor. So how did people get to Catorce? Only small, old-fashioned Mexican taxis could make it all the way. So that's how we made the trip. Several of our group were jammed together in one. The tunnel seemed darker than a moonless night and endless. I worried that the taxi would lose its lights. Albert worried that it would lose its gas tank or transmission.

Finally, we arrived. The first thing we saw was the mint. A big, waterless fountain was in front of it. A few poor Mexican families had moved into some of the long, empty houses. Everything looked as if a sudden disaster had caused the city to be abandoned by 50,000 people simultaneously.

A few children were playing around the fountain. A member of our Operation Rockhound group, the wife of a professor, joined them.

"Are you having fun?" she asked in English. The children looked at her in bewilderment.

"They don't understand you," I told her.

She asked again, as loud as she could, as if a louder voice would make them understand. The children still gazed.

The woman had been told that big, ornate keys found here were quite valuable, so she mimed picking up a key, putting it in a door, turning it and walking inside. The children burst out laughing and clapping. She gave up in defeat.

We walked into the mint, where there was still machinery. It looked old, but usable. We were astonished at the houses. They looked quite modern, even the plumbing. A few still had furniture, handmade with care.

The streets were parallel, well laid out, but in poor condition. A few perennial flowers, gaillardias, poppies, lantana, and cacti were blooming in yards and gardens with no one to enjoy them. The region is a rich botanical garden. Many species of cacti thrive at various altitudes. Some are edible or used for making beverages, while others are used for rope, paper, twine, vinegar, and molasses. The nopal and opuntia are used for fruit and jelly or jam.

The barrel cactus has delicate yellow flowers, which produce a red fruit. The Echine cactus contains a stimulant, a drug called peyote. Soap is made from a cactus called amole, a favorite of hummingbirds.

On top of a hill was an old stone church. The few children there were beggars, a couple of pesos made them happy. The stone steps had deep imprints, made by hundreds of feet entering and leaving over countless years. Everything was covered with the dust of the ages.

We had seen plenty of ghost towns of the American West, and what had drawn us to them were minerals, quite often precious metals. So of course, we had to visit the spoil piles of the local silver mines. We found pyrite, galena, quartz, calcite, gypsum, two silver ores – argentite and cerargyrite – plus one graceful black piece of native silver. The novice who found it asked, "Is black silver as good as the silver colored kind?"

We were surprised to see mica schist studded with garnets and a few staurolites. There was also some opalized wood in shades of brown and yellow. A green jasper passes locally for jade. Some authorities now report nephrite in Durango and Sinaloa.

Real de Catorce can now be reached by National Railways of Mexico and by a newly improved road. Special sightseeing trips are scheduled daily. You can even make a reservation to stay in the old city for a night. Word is that McDonald's is investigating a prime location. Is KFC next? I think I liked it better when I saw it after negotiating the zigzags in the long, dark tunnel to gaze at a city of long ago.

# ROCKY MOUNTAIN DINOSAURS

## Colorado's New Paleontological Museum Is World Class

Story and Photos by Steve Voynick

The skeletal cast of a 24-foot-long Edmontosaurus annectens, a plant-eating duckbilled dinosaur that lived 66 million years ago, is among the Dinosaur Resource Center's main exhibits.

This cast skeleton of the Triceratops prorsus was discovered by Mike Triebold in the Hell Creek Formation sediments of South Dakota.

On May 28, 2004, a unique paleontological museum opened its doors in the mountain town of Woodland Park, Colorado. Unlike most other paleontological museums or natural science museums with paleontological departments, this one is not backed by a major city or university. Instead, the $3.5 million, 18,500 square-foot Rocky Mountain Dinosaur Resource Center is privately funded and owned. And with more than two dozen full skeletal mounts of late Cretaceous dinosaurs, marine and flying reptiles, and fish, along with a working paleontological laboratory and a wealth of related exhibits, the Dinosaur Resource Center ranks right up there with the best paleontological museums anywhere.

To establish a private dinosaur museum, one must have not just a love of paleontology, but also experience and expertise in the field, hands-on knowhow, and a lot of determination. Those qualities aptly describe Mike Triebold, the owner and founder of the Rocky Mountain Dinosaur Resource Center.

To those interested in dinosaur fossils and dinosaur paleontology, Triebold is a familiar name. That's because he's also the founder and director of Triebold Paleontology Inc., one of the world's leading and most respected commercial fossil-collecting companies. Established in 1989, Triebold Paleontology operates dig sites in Montana,

the Dakotas, and Kansas, and provides services for museums and individuals that range from paleontological exploration, field-data collection, and excavation of in situ bones, to mold-making and casting, preparation, restoration, and mounting of recovered fossils.

Triebold Paleontology is also well known through its two traveling fossil exhibits, "The Savage Ancient Seas" and "The Savage Ancient World," which have been touring the United States for five years and two years respectively.

Original fossilized and cast dinosaur skeletons that have been discovered, excavated and restored by Triebold Paleontology are displayed in major museums in the United States, Japan, and Europe. Triebold himself has appeared on The Learning Channel's "Paleoworld," the Discovery Channel's "Bone Head Detectives," Fox network specials, and other television documentaries, all impressive venues for a nondegree-holding paleontologist whose interest in the field grew out of a childhood hobby of collecting fossils.

When the time came to build his Rocky Mountain Dinosaur Resource Center, Triebold had no trouble selecting Woodland Park for its location. This mountain town just west of the city of Colorado Springs is both his home and the headquarters of Triebold Paleontology. U.S. Highway 24 carries as many as 40,000 cars per day through Woodland Park during the height of the summer tourist season. And Triebold was certain that many travelers would be interested in dinosaurs and paleontology.

He made certain that these tourists won't be able to miss the Rocky Mountain Dinosaur Resource Center. Tall, artificial palm trees outside the Dinosaur Resource Center catch the eye as an abrupt departure from the pine forests of the surrounding mountains.

"The palm trees do attract attention," Triebold admits. "But more importantly, they establish a mood and a time frame. Our fossils are primarily from the late Cretaceous Period, when North America was closer to the equator and when the regional climate was much warmer and the flora more tropical. We also use tropical-flora décor in our interior exhibit halls."

Half the impressive highway frontage of the Dinosaur Research Center is floor-to-ceiling glass through which highway travelers are treated to a view of a spectacular paleontological display, two 12-foot-high cast skeletons of Albertosaurus libratus, a close cousin of the more familiar Tyrannosaurus rex, attacking the skeleton of a downed duck-billed dinosaur of nearly equal size.

Inside the Dinosaur Resource Center, visitors enter the first of two large, softly lighted, greenery-filled exhibit halls, where a background sound system plays soft, mood-setting recordings of jungle calls. Suspended overhead are soaring cast skeletons of Pteranodon sternbergi: their 20-foot wingspreads make them one of the largest flying creatures ever.

Visitors then come eye to eye with the full skeletal mount of a 24-foot-long Edmontosaurus annectens. While this duck-billed dinosaur's 2,000 small teeth were perfectly designed for grinding up its diet of plants, they provided no defense against the carnivores that stalked it, as shown by the gouge marks on its lower jaw.

"These marks tell us that some small to medium-sized predator leaped up and seized this duckbill by the throat to take it down," Triebold explains. "We think the attack was fatal, although not immediately, because some evidence of healing is seen in the 'frothy' look of the bone. So this duckbill probably did eventually die from its wounds, because the relative scarcity of frothy new bone growth does not indicate long-term healing."

Not far from the Edmontosaurus is a magnificent and somewhat intimidating mount of a massive Triceratops prorsus, one of the many specimens that Triebold discovered himself. This specimen, 80 percent complete with a nearly perfect skull, was excavated from South Dakota's Hell Creek Formation sediments in 1992. Triebold explains that this is a cast skeleton; the original bones are displayed in Japan's Gumma Prefectural Museum.

That dinosaurs came in all sizes is evident from a group of 5-foot-high Dromaeosaurus albertensis skeletons. These so-called "sickle-clawed killers" are the fierce and familiar animated "raptors" of "Jurassic Park" motion-picture fame. They were late-Cretaceous pack hunters that used long claws on their hind feet to disembowel much larger prey.

In the Prehistoric Oceans exhibit hall, raucous cries of seabirds, haunting strains of whale song, and the distant sound of pounding surf make it easy to imagine being immersed in the dark, deep water of an ancient sea. Glass display cases are filled with the fossilized teeth, vertebrae, and tail sections of various forms of marine life, while suspended overhead is a superb collection of mounted skeletons, beginning with Tylosaurus proriger, a mosasaur that was the undisputed ruler of the Cretaceous seas. Paddle-shaped forelimbs on this 30-foot-long specimen show that it was highly evolved for rapid swimming. Among its most interesting features are its teeth. To the rear of the huge set of backward-pointing teeth, useful for holding prey, is a second set of jagged teeth that aided in the disposal of its still-struggling prey. This particular specimen was found in 1911 in western Kansas, but languished in storage at Kansas University until 1997, when Triebold was called upon to restore it.

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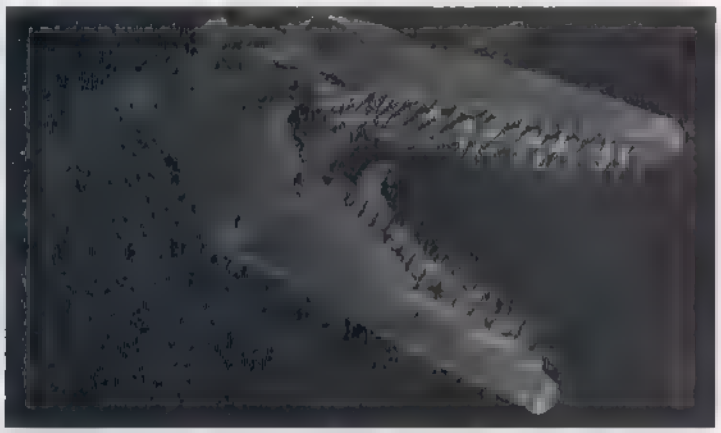
**In the Prehistoric Oceans exhibit hall, overhead displays of fossil fish make it easy to imagine being immersed in a Cretaceous sea.**



**The Resource Center displays the skull of a 30-foot-long Tylosaurus proriger, a marine reptile that was the undisputed king of the Cretaceous sea**

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## Rocky Mountain *from page 67*

Also "swimming" overhead is an equally remarkable skeletal cast, this one of the giant marine lizard Elasmosaurus platyurus. This specimen, which measures 42 feet in length—most of that neck—and would have weighed nearly 4 tons in life, occupies an interesting niche in paleontological history. It was discovered 1867 at Fort Wallace, Kansas, and collected the next year by a U.S. Army surgeon.

The bones were first studied by the well-known paleontologist Edward Drinker Cope (1840-97), a curator at the Philadelphia Academy of Sciences. But in his reconstruction of the disarticulated bones, Cope mistakenly placed the head of the Elasmosaurus at what was really the tip of the animal's tail. Cope's paleontological counterpart at Yale University, Othniel Charles Marsh (1831-99), humiliated Cope by pointing out this blatant error to the international scientific community. This touched off a bitter rivalry between Cope and Marsh that would culminate in the famed "fossil wars" of the 1870s and '80s in Colorado and Wyoming, a heated competition between the two paleontologists to discover, excavate, name, and display ever bigger and more complete dinosaur skeletons.

Excellent educational displays and information about paleontology and geology make the Dinosaur Resource Center's superb collection of skeletal mounts even more meaningful. More than 30 such displays enlighten visitors on paleontological exploration techniques, Colorado fossil-hunting areas, paleontological field-collection methods and tools, the history of North American paleontological excavation, the rise of commercial fossil collectors, tectonic plate movement and paleogeography, geological eras, the history of the universe and the evolution of Earth, the evolution of life on Earth, the great extinctions, bone identification techniques, and the fossilization process, among other topics.

Special exhibits relating specifically to dinosaurs include modern fossil hunting, Colorado's dinosaurs, anatomy and pathology, behavior and diet, skin and coloration, and even several "life restorations," life-size, fleshed-out models of what paleontologists believe living dinosaurs actually looked like, based on the latest information available.

Along with numerous scientific illustrations, the Dinosaur Resource Center also showcases dinosaur art. Full-color paintings by such renowned dinosaur illustrators as Louis Rey and Todd Marshall depict extrapolated life scenes of dinosaurs in their ancient environments. Visitors also view a display of movie posters going back 60 years that star such prehistoric monsters as Godzilla and The Beast from 20,000 Fathoms, all of which, of course, are loosely based on dinosaurs.

Triebold personally designed the Dinosaur Resource Center's "storyboards," the descriptive information provided for each display, with the varied preferences of visitors in mind.

**Original fossilized bones that have been completely cleaned and restored are stored in the clean room of the Center's Paleontology Laboratory.**

"Some visitors have a serious interest in paleontology, while others require more introductory-level explanations. And some visitors can spend an entire day here, while others have only a few hours," Triebold explains. "So we presented information at each exhibit in several versions: condensed, in a middle-level form, and in fully detailed versions. This is the only way to accommodate all levels of visitor interest and time availability."

Several large viewing windows, along with storyboards and video monitors, enable visitors to observe activity within the adjoining paleontology laboratory where staff technicians are busy cleaning, stabilizing, restoring, molding, casting, and mounting the new fossils specimens that will eventually be displayed in the exhibit halls.

*continued on page 70*

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## Rocky Mountain *from page 68*

"The laboratory work is very time-consuming," Triebold explains. "It's not uncommon to put 20,000 hours into cleaning, restoring, and casting a single skeleton. Then factor in the considerable time already spent in field excavation, and you can see why a single, full-skeletal cast of a dinosaur can easily cost $1 million."

The close association with Triebold Paleontology provides many advantages for the Dinosaur Resource Center. One example is the museum's work with "Sir William," perhaps the youngest and smallest of the approximately 35 fossilized Tyrannosaurus rex skeletons that have been recovered over the past century. Walter Stein, field collections-manager for Triebold Paleontology and curator at the Rocky Mountain Dinosaur Resource Center, discovered this specimen in the summer of 2002. Stein and Triebold had been hunting for fossilized marine reptiles in central Montana's Bear Paw Shale formation when they noticed an exposure of the fossil-rich Hell Creek Formation. Almost immediately afterward, Stein found the fossilized skeleton of the small T. rex weathering out of the sandstone.

After two and a half seasons of intensive field excavation, Sir William's fossilized bones were finally moved to the Dinosaur Resource Center in 2004, just in time for its grand opening. Visitors can watch the ongoing restoration of these bones in the Resource Center's preservation laboratory. Stein estimates Sir William's age at about 15 years, his length at 20 feet, and his weight at 3,500 pounds at the time of death. That's only half the size of a full-grown T. rex. Sir William is nearly 50 percent complete, and the recovered bones include elements of the skull, forelimbs, hind limbs, pelvis, and backbone.

Preliminary preparation and analysis of the skeleton are providing additional insight into T. Rex growth patterns and behavior. Sir William's bones are not complete – and for good reason. His remains were crushed, broken, and chewed upon by numerous late Cretaceous carnivores, possibly including another T. rex. If pathological bone analysis confirms this theory, Sir William will represent the first evidence of tyrannosaur cannibalism.

During 2004, Triebold Paleontology was also called upon to help save a priceless fossilized body impression of a carnivorous dinosaur. The city of St. George, Utah, had been constructing a museum of a dinosaur-track site when workers uncovered this rare body impression. The animal was apparently walking across a river when it paused, then crouched down on its hindquarters and waited, leaving behind an impression of its pelvis, hind legs, and forefeet in the soft mud.

Unfortunately, the impression was found right at a corner of the planned museum-and the city, facing a tight budget, could not halt construction. Unable to mold the impression, site paleontologists were quickly running out of time, supplies and money. Receiving their request for assistance, Triebold rounded up gallons of latex and other molding materials, then donated both the supplies and technical advice. The site paleontologists managed to obtain a mold of the rare body impression just in time, and now the Rocky Mountain Dinosaur Resource Center is looking forward to displaying a cast of the dinosaur's body impression.

The Rocky Mountain Dinosaur Resource Center in Woodland Park, Colorado, houses a world-class collection of paleontological exhibits.

With its paleontological laboratory slowly turning out a steady supply of new skeletal mounts, the Resource Center's exhibits are never static. "We change and rotate our exhibits frequently," Triebold says. "When visitors return here a year from now, about half the exhibits they see will be new."

In addition to its two big exhibit halls, the Resource Center also provides a children's play area complete with dinosaur-related toys and activities. Prehistoric Paradise is a spacious gift shop that is stocked with jewelry, clothing, a large selection of fossils and fossil casts, mineral specimens, mineral- and paleontology-related books, posters, videos and CDs, and quality table top replicas of dinosaurs and other forms of prehistoric life. There are also racks of Indiana Jones type khaki clothing and hats that will make children look like field paleontologists.

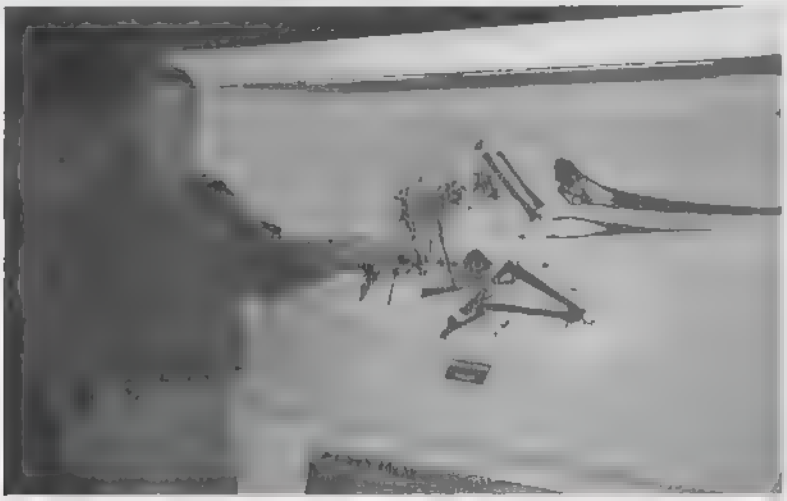
The Resource Center periodically hosts special guest speakers at scheduled lectures. To date speakers have included such prominent scientists as dinosaur paleontologist Robert Bakker, author of *The Dinosaur Heresies*, ichnologist (dinosaur-track specialist) Martin Lockley, paleontologist Ken Carpenter of the Denver Museum of Nature & Science, Phil Currie of Canada's Royal Tyrrell Museum of Paleontology, extinction theorist Paul Janke, and the Resource Center's own curator, Walter Stein.

The Rocky Mountain Dinosaur Resource Center is well worth a visit, both for its superb paleontological exhibits and because it has been designed from the ground up with the needs and interests of visitors in mind. Visitors at all levels of paleontological interest relate easily to the exhibits, something that is not always possible at other museums. That's because the Dinosaur Resource Center's exhibits reflect the enthusiasm, experience and creativity of Triebold himself. After all, anyone who can parlay a childhood interest in collecting fossils into a leading commercial fossil-collecting company and then a world-class private paleontological museum certainly knows something about designing dinosaur exhibits.

After a visit to the Rocky Mountain Dinosaur Resource Center, visitors seeking additional paleontological attractions won't have to drive far. From Woodland Park, Florissant Fossil Beds National Monument, which preserves the leaf- and insect-fossil-rich sediments of an Eocene lake bed, is just 15 miles west along U.S. Highway 24. And Cañon City, an hour's drive south, has the Dinosaur Depot Museum and the Garden Park Fossil Area, site of many historic excavations of Jurassic dinosaurs.

Woodland Park is 18 miles west of Colorado Springs, Colorado, on U.S. Highway 24. The Rocky Mountain Dinosaur Resource Center is open from 9 a.m. to 6 p.m. Monday through Thursday, 9 a.m. to 8 p.m. Friday and Saturday, and 10 a.m. to 5 p.m. Sunday. The Resource Center is closed on Thanksgiving, Christmas, and New Year's Day. Admission is $9.50 for adults, $8.50 for seniors age 65 and over, and $6.50 for children ages 5 to 12. Children 5 or under are admitted free.

For additional information, contact the Rocky Mountain Dinosaur Resource Center, 201 Fairview St., Woodland Park, CO 80863; (719) 686-1820, or visit the Web site www.rmdrc.com.



Mike Triebold is the founder and director of Triebold Paleontology Inc., one of the world's leading and most respected commercial fossil-collecting companies.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# Making and Selling Jewelry

## Part I: Finding Your Niche

Story and Photos by Rick Olmstead

Most people I know are completely in love with their hobbies, especially lapidaries and metalsmiths. With other hobbies, such as biking, painting or boat building, few people get to see and appreciate the results of your efforts unless they visit your home or are personally involved in some of the same things. Jewelry, however, by its very nature, is revealed to a broad spectrum of people from all walks of life. Even those who have no inherent interest in our hobby are often keenly interested if they see you wearing an exceptional piece of jewelry and they find out that you "made it yourself."

I think most of us rockhounds can trace our first interest in rocks back to a much earlier time in our youth. Mine began during my elementary school years in rural Minnesota. Each spring, as the highway department spread a new layer of gravel on the road in front of my family's home, swarms of neighborhood children would follow the gravel trucks, scouring the piles for treasures of agate and jasper. Vacations became an exercise in endurance for our family car, which came home with a substantial portion of the western United States loaded into its trunk each summer.

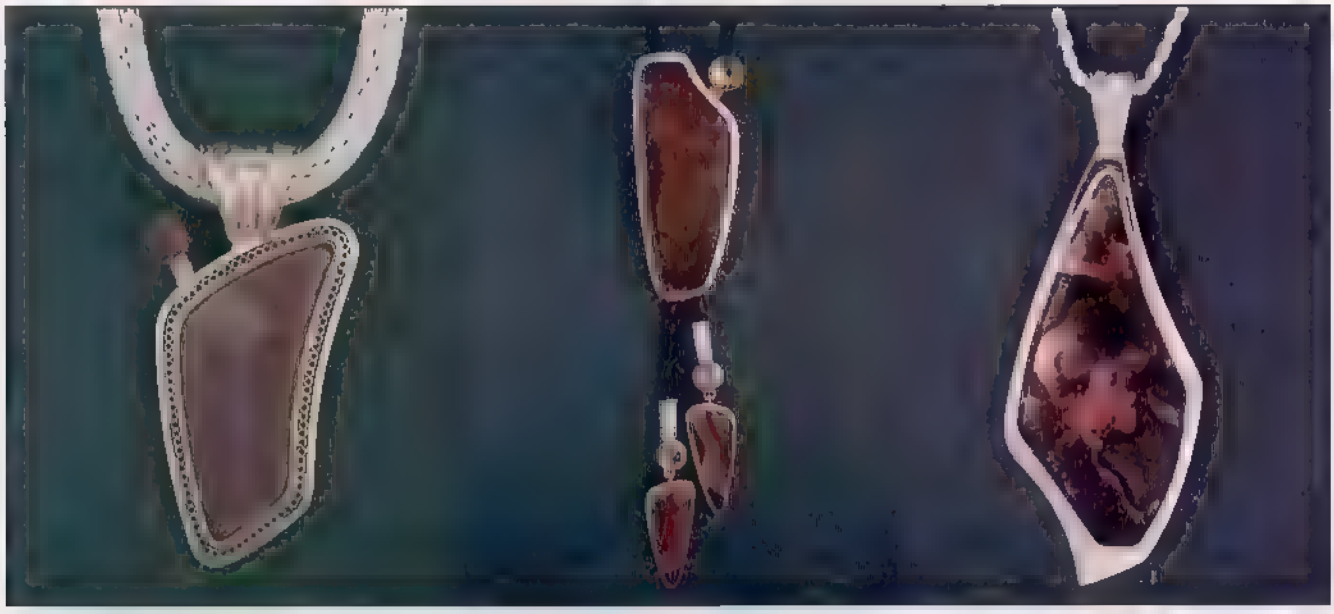
My interest in rocks waned somewhat as competing interests during high school and college took precedence. Several years after college graduation, a newly acquired interest in skiing once again turned my vision westward, and I found myself planted in the area around Boulder, Colorado, where I lived for 20 years. It was there that persistent friends from the Flatirons Gem & Mineral Club rekindled my interest in rocks, and things began to change.

You can carve yourself a niche in jewelry sales through unique designs and outstanding quality. Try finishing the back of a bracelet to be a hidden part of your overall design.

My new cadre of friends had something that I never had: stone-cutting equipment. These friends allowed me to practice and learn on their equipment. Since my college major was in Industrial Arts, my skills transferred easily, and I quickly became proficient at cabochon cutting. Free forms, gem carvings, and intarsia soon followed. I quickly acquired a drawer full of polished stones, but had no practical use for them.

The next natural step, of course, was to find someone to teach me the skills of silversmithing. I found this in a community education class taught by an accomplished local jeweler. After three sessions, I was equipped with the most basic skills. At about the same time, I began entering competitive lapidary displays in local gem shows. A local professional gem cutter noticed the cases and encouraged me to try selling some of my loose stones. I took his suggestion and rented a space at the Flatirons club annual show the following year, where I met with limited success. A seed had been planted.

After several more years had passed, I once again found change at my doorstep. Family, job and economic circumstances were simultaneously pointing toward a move to Boise, Idaho, which I now call home. Almost immediately upon getting



Don't be afraid of using irregularly shaped stones. Just add an accent stone to make the piece look balanced.

Use natural patterns in the stone to suggest the shape of your final design.

Pictures in the stone are a real attraction to customers and a strong selling point. Especially ones like this rare natural cameo.

settled, I began looking for a gallery where I could sell some jewelry, and found a quality artist-owned one where my work has been displayed for the last five years.

I have spent the last 17 years on a path of experimentation, discovery and learning that has consumed much of my time and resources. To me, it has become much more than a mere hobby. I find jewelry making strangely addictive, and it has become my passion. I do not consider myself an "expert"; although I have learned much along the way, I also have much yet to learn. Perhaps, as you read on, you will allow me to share some my experiences concerning the making and selling of jewelry.

## FINDING YOUR NICHE

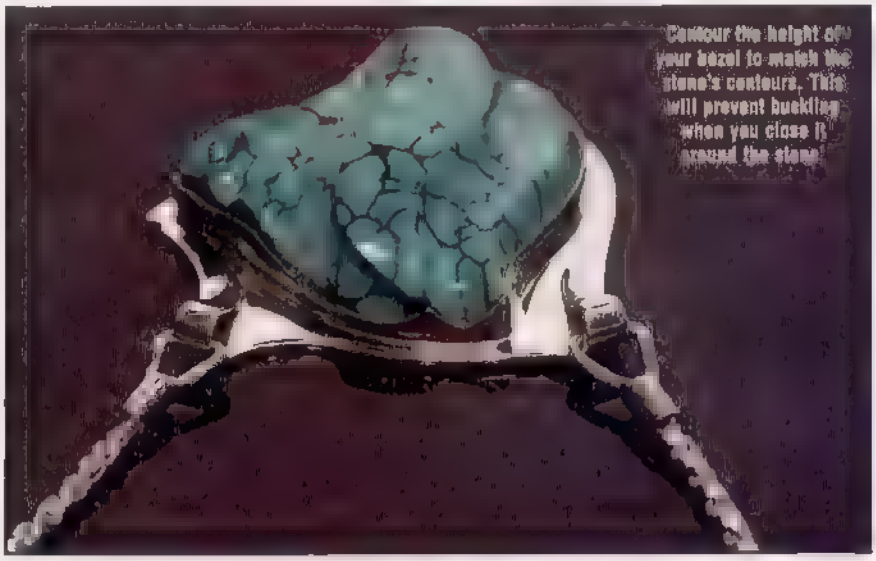
Nearly everyone's dream job is to pursue his hobby as a full-time occupation. My first piece of advice in this regard is, Don't quit your day job! If you are like me, capital is scarce and you will need to build it slowly, along with your customer base. Jumping in with both feet and risking everything is just a little too uncomfortable for me. There is much opportunity in the jewelry field and there is a built in demand for the finished product, but you will have a massive amount of competition, often from enterprises overseas, where people work for incredibly low wages. You cannot compete with them and be successful. You need a niche. It can be found in unique designs, outstanding quality, rare stones, an exclusive sales venue, a personal clientele, a personal reputation, or something else that would be difficult to duplicate in mass production.

One of the best niches you can have is the fact that you are hand-making what you sell. Your one-of-a-kind designs cannot be found elsewhere. If your designs are very simple, you can emphasize that your stones are cut specifically for a outstanding pattern within the stone. If they are complex, their uniqueness will be obvious. I would suggest that you make both complex and simple designs. Challenge yourself. I have found that complex or spectacular designs attract a lot of attention and will make it easier to sell your simpler, less-expensive pieces.

Another niche is quality work. A lot of production jewelry, like that seen at large trade shows, looks very nice at first glance, but with a closer look you may find treated stones, thin metalwork that can't be repaired if broken, cookie cutter design, electroplating, tumble polishes on metal work, or other shortcuts to keep it inexpensive.

A few things really stand out in a piece of handmade jewelry if it is not crafted with adequate attention to detail. The most obvious deficiency is a sloppy bezel. Crinkly or folded corners on bezels are common when sharp corners are present on the stone or when bezels are made too tall. Another is an unfinished back. This gives your work a "crafty," rather than professional, feel. It does not necessarily have to be a high finish (as I personally prefer), but can be satin-brushed, sandblasted, or spot finished. You may even want to add embellishments to make the back a hidden part of your overall design. The back is where you can and should sign your name. Make it look nice. If it is good enough to sell, it should be good enough to sign, so associate your name with good workmanship and let it be seen by your customers as a seal of quality.

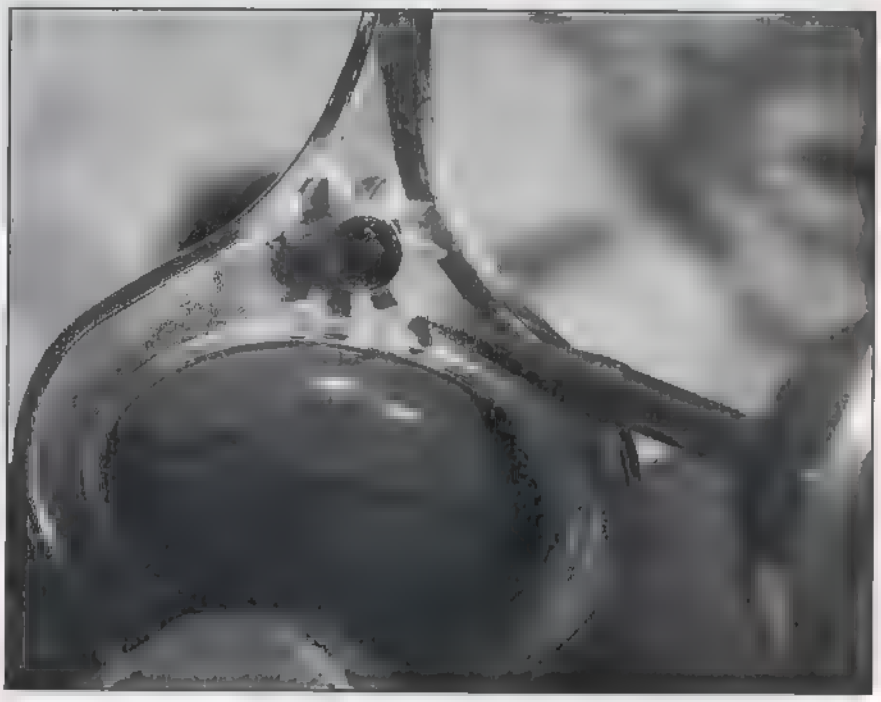
*continued on next page*



A third thing that detracts from the quality of your work is using too much or too little solder in joining the bezel to the back. Using too much leads to additional work to mechanically remove the excess. Too little leaves voids, or porosity, in the joints.

### VENUES

There are many possible venues in which to sell your work, and to a large degree, the ones you select will determine what your product mix, prices, displays, selling style, and competition will be. Of the venues I have tried, I have found gem shows and galleries to be the most productive. When you choose either of these venues, you will generally have to pay a booth fee or a commission from your sale. I choose to view this expense as a marketing fee. These shows or galleries are bringing together a narrowly targeted group of interested customers to view your work. Isn't this essentially what marketing is? Other venues to consider are gem shows, art shows or fairs, jewelry stores, flea markets, and your own Web site. The possibilities are endless.



**A pointed diamond burr in your flex shaft makes an excellent texturing tool for backgrounds. It also does a good job of hiding fire scale that cannot be removed. It leaves a bright, sparkling finish.**

### SHOWS

If you are new to the idea of selling some of your work, the best place to give it a try is probably your local rock or gem club show. If you are a member of one, you will have a volunteer sales staff of fellow members and friends sending customers to your booth. After the initial show fee, there is generally no commission, and you need new merchandise only once a year. It is the best of all possible worlds for a hobbyist. People attending gem shows, however, are often looking for economical items, and it will be challenging to sell more expensive jewelry except at some of the larger or more exclusive national and international shows.

Other types of shows, such as art and craft shows, will bring in customers with a much broader range of interests, so you will be competing for attention with many other art forms. A large show of this type, however, can draw in excess of 100,000 visitors in a single weekend, so the numbers are favorable. The larger and more exclusive ones will require you to go through a very competitive jury process, and space fees can be fairly expensive. They also will often be located some distance from your home, resulting in travel and lodging expenses.

### WEB SITES

I consider the impact of a Web site to be highly overrated unless it is properly done. I liken it to the microwave oven in your kitchen, it is very nice to have, but it is not the workhorse of the kitchen. It is an accessory. Selling jewelry through a Web site alone is mere chance. Type "jewelry" into your browser sometime to see how many sites are listed, and you will see what I mean. My last count was nearly 12 million. The chances of a customer landing on your Web site at random is slim enough to make the lottery look like a good bet.

The real power of a Web site is in keeping an existing customer base informed about what you have to offer and in giving word-of-mouth contacts a place to go to find out about you and your work. You must promote your Web site in other venues in order to make it work for you. Every point of customer contact should mention your Web site address.

When you have a sale, ask your customer if she would be willing to pass a few of your business cards out to her friends. Then place several of them, with your Web address prominently displayed, in the customer's bag. If a customer likes your work and is happy with her purchase, she may be willing to refer you to her friends. People prefer not to buy blind, but from people they already know. A referral from a friend they trust is the next best thing. If your customers are willing, make them your "friends" and get them working for you.

The advantage of Web sites is that you can have immediate, international exposure at a very low cost. Don't let computer phobia get the best of you. A small, informational Web site with an e-mail address and photos and prices of your work is fairly easy to create. Most newer computers come with simple Web page creation software already loaded for use. Many Web browsers and Web site hosting companies also have these types of programs available. Some of them are completely "canned," so all you have to do is drop in your photos and text.

If you want to do e-commerce, there are other things to consider, such as encryption for safe credit card sales and setting up a shopping cart. Shopping cart software is available on the Internet, and some of it is freeware. My own Web site is purely informative for now, and actual business is done through the mail. This protects both my customers and me, because postal fraud laws apply to financial transactions done through the mail.

For those who do not want to promote their own site, an Internet auction house is another option. An advantage is that final prices are determined by the market, and it is sometimes possible to get much more for a unique piece than you could by placing it in a retail location. Competitive bidding can cause people to do crazy things with their money. You can set a minimum bid to protect yourself, but most people set these low to encourage bidding at the beginning of an auction. Credit card transactions are taken care of by the auction house for a minimal fee. You can

My interest in lapidary began with a childhood interest in rockhounding and developed through my college training in Industrial Arts.

also link your item listing to your own Web site if you wish, but you will not need your own site at all to have an Internet presence using this method.

**GALLERIES**

If you choose — and if you are accepted — to show your jewelry at a gallery, you can expect to give up 30 percent to 50 percent of the sales price as a commission, so price your work accordingly. The big advantage to working with galleries is that the time you must personally involve in selling is essentially zero. Theoretically, your jewelry can be shown anywhere in the country to a diverse and large audience, with no requirements from you except to provide the product. People shopping at galleries are looking for original art and usually expect to pay a little more for their purchases, so your jewelry can generally be a bit more upscale. You should be able to work with better materials and sell more expensive items there. Be careful, however, not to become overcommitted to too many galleries at once. They like to rotate their merchandise periodically and you may find it difficult to keep them all supplied.

*Rick Olmstead is a working metalsmith, lapidary and jewelry designer located in Boise, Idaho. He can be contacted through his Web site www.gemquest.com, where more photos and information about his work may be viewed.*

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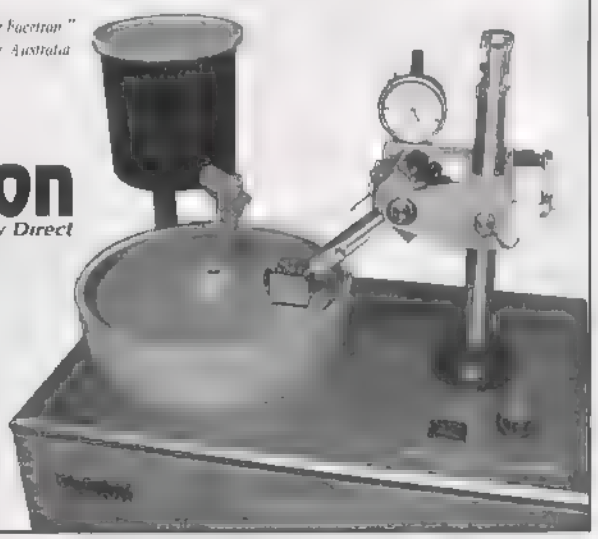

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# ROCK SCIENCE

by Steve Voynick

## Meeting the "Moho"

During the past 50 years, one of the most elusive targets of underground exploration has been the Mohorovicic Discontinuity, or as it is familiarly known, the "Moho." Named for Croatian geologist Andrija Mohorovicic, who in 1906 used seismic data to predict its existence, the "Moho" is the boundary between the Earth's crust and its upper mantle.

Seismic and other geophysical data indicate that the Earth's internal structure consists of a solid inner core, a molten, nickel-iron outer core, a massive, semisolid-to-solid rock mantle, and, finally, a thin, hard, outer crust that varies in thickness from as much as 25 miles at the continents to as little as one mile at certain points of the sea floors.

Ever since Mohorovicic predicted the boundary's existence, scientists have dreamed of taking rock samples from the upper mantle, knowing that they would provide invaluable information about the Earth's age, structure, internal processes, and the then hotly debated theories of plate tectonics and continental drift.

But hopes of sampling the mantle had to wait for advances in diamond drilling, an exploration method that employs rotary, hollow, diamond-tipped drills to recover core sections of subterranean rock. In 1955, when gas-exploration drillers recovered cores from the then-record depth of 24,000 feet or more than 4.5 miles, geophysicists realized that drilling to the Moho Discontinuity was a distinct possibility, especially by utilizing the new technology of marine drilling.

In 1958, the U.S. government launched Project Mohole, an effort to drill through the Moho and into the upper mantle from a shipboard drilling platform in the Pacific Ocean. But after eight years, with only a 610-foot-deep hole into an 11,700-foot-deep sea bottom to show for their efforts, the only discontinuity Mohole encountered was one of government funding, which resulted in its cancellation.

Then, in 1974, drillers on an Oklahoma gas well, using a conventional, surface-powered, rotary drill "string," set a new deep-drilling record of 31,441 feet, nearly six miles. Drilling was halted only because the bit "ran wild" when it bored into a deposit of molten sulfur.

By then, the Soviet Union was taking the lead in deep continental drilling. In 1970, at Zapolyarnyy on the Kola Peninsula, drillers had begun sinking a hole with a revolutionary "turbo" drill, which pumped drilling mud through a tiny turbine at the end of a stationary drill string to rotate only the bit. When the project ended in 1994, the bit was into 2.5 billion-year-old gneiss at a depth of 40,229 feet (nearly 7.6 miles), but still far from the Moho at that point in the crust. Based on recorded data, the temperature at a depth of 50,000 feet (more than 9 miles, and still short of the Moho) would be 300 degrees Celsius (572 degrees F), which is at the endurance limit of drill steel.

Abandoning the idea of reaching the Moho by drilling through thick continental crust, geophysicists instead refocused their efforts on drilling into the much thinner and cooler oceanic crust, but only after first determining by advanced seismic methods exactly where the crust is thinnest. Seismologists identified one such "thin-crust" target at the intersection of the Atlantic Ridge and Atlantic Fracture Zone, midway between Florida and Africa. Early in 2005, the drilling ship *JOIDES Resolution* (JOIDES is an acronym for Joint Oceanographic Institutions for Deep Earth Sampling, an American-Japanese partnership) positioned itself over the site in 5,350 feet of water and drilled a 4,644-foot deep hole into the sea bottom. Although the hole laterally missed a high point of the Moho, and thus the underlying mantle by a mere 1,000 feet, the core samples taken represent the lowest part of crustal rock ever recovered.

It seems likely that in perhaps just two or three years, deep drillers will finally penetrate the Moho Discontinuity to retrieve the first core samples from the Earth's upper mantle, cores that will be substantially different in texture, composition and chemistry from any crustal rock. Many questions about the Earth's crust and mantle, and about the planet itself, promise to be answered when science meets the Moho.

FIELD TRIP

The predominant color of the agates collected at the #5 site in the Buffalo Gap National Grassland is translucent blue. They may have tiny white, black and brown inclusions.

# COLLECTING GRASSLAND AGATES

## Multicolored Gems from Nebraska's Buffalo Gap

Story and Photos by Kennth H. Rohn

I was traveling north on U S Highway 385 in the extreme southwestern corner of South Dakota It was a beautiful, bright mid-summer morning I had spent the night in Nebraska, and looked forward to what lay ahead in this vast, rolling prairie country spread out before me. My plans were to investigate an area just north of the state boundary known as Buffalo Gap National Grassland

Buffalo Gap encompasses an immense area of land in this part of the state Scattered tracts totalling nearly 60,000 acres stretch from the Wyoming-Nebraska border in Fall River County all the way to the northeast as far as the town of Kadoka in Jackson County, on both sides of Interstate 90 It encompasses over a half-million acres of land south of the Black Hills and west, north and south of Badlands National Park.

With only a limited amount of free time on my hands, I decided to investigate an area that looked inviting off U S. Highway 385, an area adjacent to Fall River County Road 5

Without a doubt, it would be an impossible task to investigate more than a small portion of this wonderful land on foot As a matter of fact, large tracts of it are what one might call pristine, with no access by auto Some of it is enclosed by private, state, county, and tribal lands, but the total acreage is so

vast, this need not be a problem for us rockhounds. If one were to enter non-BLM land to reach BLM property, permission to do so is mandatory. I would suggest visiting the nearest BLM office to ask questions and purchase a map of these vast holdings. This way, you'll know exactly where you are at all times.

There are two BLM offices in South Dakota: Buffalo Gap National Grassland, Fall River Ranger District, 209 N. River, Hot Springs, SD 57747, (605) 745-4107, and Buffalo Gap National Grassland, Wall Ranger District, 708 Main St., P.O. Box 425, Wall, SD 57790, (605) 279-2125. They have much free advice and tips about their grassland and many brochures on the area.

While traveling north on U.S. Highway 385, Fall River #5 is the first county road one comes to that goes in a westerly direction. You can take it all the way to the town of Ardmore and beyond to the Nebraska state line. It's a somewhat narrow gravel road, but conditions were good for the short distance I traveled on it. It's better than a few that I've traversed, while investigating collecting sites.

A half-mile north of County Road 5 on U.S. Highway 385 you'll find the BLM Pioneer Rest Area on the right side of the highway. This is a good reference point in case you've passed County Road 5 without noticing it. Right across the highway from the rest area is BLM land. Although I didn't investigate this place, it may also have potential collecting sites. It's fenced because this is cattle country and ranchers are allowed to graze their critters here, but it's still open to outdoor enthusiasts and rockhounds.

I didn't check the odometer after crossing the state line, but while studying the Buffalo Gap map, I noticed it's just a bit over four miles to County Road 5.

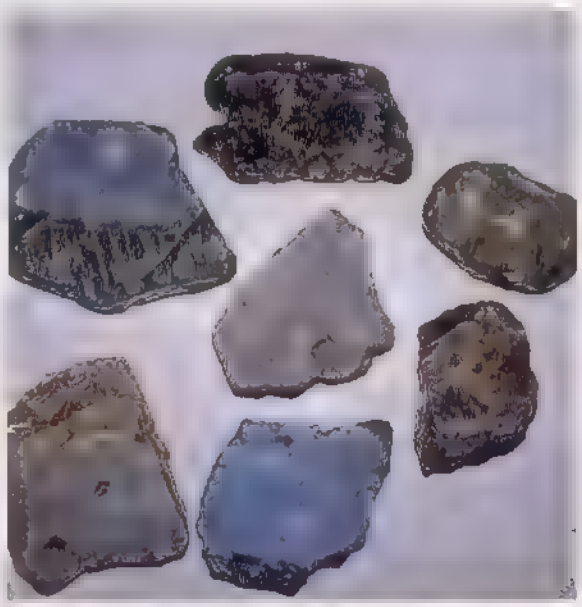
I had never been here before and didn't really know what to expect, but it looked inviting, and this is where the adventure comes into play. I don't know how many times I've driven along roads similar to this in various parts of the United States, searching the landscape for clues, only to turn around after a reasonable amount of time and head for the highway. One of those clues in prairie country is trees, particularly those growing in a line that meanders across the landscape. Cottonwood trees thrive in this country. They always grow near a water source. This is a good indication that a creek or riverbed is nearby. Where there are riverbeds there are always ravines, draws and washouts. These natural cuts in the landscape always give a cross section of what lies beneath the surface. During the dry season, these are excellent areas to search.

The fossils scattered in the creek bed gravel at the #5 site include specimens of baculites. Some retain their mother-of-pearl surface.

In the grassland, quite often there are gravel beds exposed on the surface, a good distance out from the right of way and sometimes hidden from view while in your vehicle. Having passengers in the car increases your chances of spotting such anomalies. One clue to these beds is that the vegetation is sparse. Still, they're very easily missed as you drive along. They are, often as not, in a ravine between two hills or on a hillside, where erosion has had a chance to expose them.

One solution is to park your vehicle, climb through the fence, and walk out into this vast, undulating grassland for a personal investigation. I find this invigorating after sitting in my truck for long hours. You may or may not find an agate bed, but you'll be exploring new ground, ground that, aside from wildlife and cattle, nothing has set foot on in decades.

A word of caution: If you intend to walk beyond sight of your vehicle or the road, go prepared. It only takes a few minutes to gather the necessary equipment. It's a good idea to carry a compass, unless you're good at finding your bearings by reading the sky and landmarks. It's essential that you do keep track of where you are while out in this grassy sea, where most everything looks alike. The rolling, hilly nature of Buffalo Gap can also cause confusion in unfamiliar territory, particularly on a cloudy day. It's best to play it safe. Carry a container of water or bottle of pop, or both. A hat or cap can keep your head protected while in the field, and a pair of sunglasses with ultraviolet protection will protect your eyes. As strange as it may seem, our eyes can actually become sunburned from too much exposure on a bright day. This is not only painful, but dangerous. Good, solid leather shoes with 8-inch tops are my choice for hiking cross-country on a field trip.



Buffalo Gap agates vary in color and shape. The rounded gray one (top right) is moss agate similar to that from Montana.

While exploring the grassland, in most cases, you'll be far from the nearest community. Consider safety first. Keep away from dangerous-looking overhanging cliffs. Be careful where you walk. Sometimes the most innocuous looking things can be the most dangerous. I am referring to that pretty little prickly pear cactus that grows in profusion in much of Buffalo Gap National Grassland. The spines can and do penetrate the canvas shoes that many of us wear. They are painful and can ruin an otherwise great day if you accidentally brush against or step on one. Tripping over loose rocks has also caused painful sprains and injured ligaments. The cattle here are semi-wild, stay away from them.

*continued on next page*

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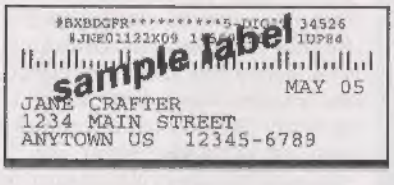


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## Collecting Grassland Agates *from page 89*

Buffalo Gap is home to many wild animals such as antelope, deer, skunks, foxes, badgers, and prairie dogs, but they are usually long gone before you see them. This country is also the home of rattlesnakes. Watch where you step while in the field. As I've probably mentioned in other articles, I have yet to encounter one.

I turned off U.S. Highway 385 and drove for approximately three miles on County Road 5 to a branch in the road. (There's a busy railroad track along the way, so use caution.) I was in luck! Just beyond the junction, I saw a bridge crossing a stream. Trees were growing abundantly all along this watercourse. At the junction of this ranch road, there's a triangle, with the "Y" going in either direction onto County Road 5. When I drove over the bridge, I was disappointed to see water in the stream below. So I turned around and took the ranch road south a very short way, no more than a city block, when I saw the familiar BLM sign on my right. A two-rut road leads off into the hinterland adjacent to the tree-lined creek. No matter how inviting these two-rut roads look, I avoid them. The possibility of getting stuck far from help is all the justification I need.

Other minerals, like this rose quartz nodule, can be found at the Interstate 90 site.

It was time to investigate. I pulled off the road and parked near the opening in the fence. The rule in cattle country is to leave gates as you find them. In this case, there is no gate, and I wondered how the ranchers can keep their cattle from straying. On a post next to the opening in the fence, a sign stated, "You are entering BLM land."

I was anxious to see what may lie in the ravine not more than 100 feet from where I parked. I stepped over to the edge and looked down. It was rather deep from where I stood, perhaps 20 feet to the bottom. The bed was dry. Cattle had been using it for a trail to the water under the bridge. It didn't take me long to gather my gear, which included my rock pouch, a heavy-duty plastic bag, a candy bar, a bottle of water, and my camera. I found a pathway that the cattle had used to get down into the ravine and I was soon exploring a wonderful land of the past. (I encountered no bovines while here.)

Shrubs and small trees are growing here and there in the creek bed, indicating to me that this creek is dry during a good portion of the year. During storms or spring run-off, perhaps, the water in this stream is high, as evidenced by clumps of dead grass bound up on shrubbery at waist height. This indicates that the best times to search here are mid- to late summer and early fall. Gravel bars are heaped up in places where something had stopped the flow of material, such as a downed tree, a boulder, or a sharp bend in the creek. In most places, this watershed is no more than 25 feet wide.

It was only a matter of minutes before I began discovering wonderful agate nodules in the first gravel bed that I encountered, right below the cow path where I had entered the cut. Agates are scattered everywhere. Some were protruding with only a tip showing through the dry mud bottom. The predominant color of these magnificent stones is a translucent blue, though quite a few are chocolate brown. Some have tiny specks of white, black and brown inclusions throughout the surface. Most have a peculiar shape. They're flat, often rectangular. The thickest ones that I collected are about 1½ inches thick. Some are layered in black, blue, white, and gray bands. The coloration is very intense. Some are so dark that no light shows through at all when held up to the sun.

The biggest flat specimen I collected that day is 5 inches by 3 inches by 1¼ inches. One half of the top surface is sky blue, while the other half is such a dark gray that it appears black. The entire bottom is very dark gray. I held it up to the light after I washed it at home, and it has a complex inner structure, with an icy white layer, plus orange, brown and creamy inclusions showing here and there around the edges. The center is too dense to see any light through it. It also has a striated surface with many straight-line ridges covering it. Adjectives do not do it justice. It's beautiful.

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The appearance of many of these agates tells me that they have not moved very far from their origin. They show practically no wear at all. The shape of these stones indicates that they formed in one flat layer and were broken up into irregular, flat discs before coming to rest in this creek. By the way, I don't know the name of the creek. It may be Horse Head Creek or a tributary of it.

I discovered several gravel beds in this dry creek. Every one of them has an abundance of agates scattered about. Some are rounded and do show wear and reduction from tumbling in some ancient watercourse. One of the large ones that I collected fills the palm of my hand and is a mottled brown with black and gray inclusions.

I didn't investigate more than perhaps a half-mile of this creek bed. I didn't have to. The agates and fossils are so abundant it amazed me. I would imagine that right under the surface are many more, hidden from view. I also got a happy surprise. Lying amongst the agates, resting prominently on the surface, were the fossilized remains of several baculites. I picked up a nice selection of them. The largest one is 3½ inches by 3 inches by 2¼ inches, supposedly large for baculites. It is a solid gray mass showing a strange, bulbous end structure. The positive way to identify them is by the sutures etched in creamy white jagged lines across the outer shell. Not much of the pearly surfaces remain.

Baculites are of the genus polythalamous, a many-chambered cephalopod. They are of the family ammonitidae. None of these sea creatures remain alive today. They have been extinct since the end of the Cretaceous Period some 60 million years ago. They are found in the Pierre Shale formation, which covers much of this area of South Dakota and parts of Wyoming and Nebraska.

As I walked along and looked up at the embankments that were carved out of this clay earth, I could see areas where agate nodules were just emerging. Some had tumbled partway down the embankment and lay scattered about. Oddly enough, I found only a few pieces of gray petrified wood and one amber-colored, translucent specimen of agatized wood during my walk.

It had been a most wonderful adventure into the past, and it was near lunchtime when I emerged from the riverbed. My pouch was bulging with agates and a few fossils, including a cast of a clam with its slight iridescence still showing in places. My plastic bag was also beginning to get heavy.

I did not see any vertebrate fossil remains or artifacts, but that doesn't necessarily mean none are present. If you do happen to discover any, do not disturb them; instead, locate them on your map, then contact the nearest U.S. Forest Service office. They are clues to the distant past and may help solve some of the mysteries of the early history of Earth.

**The badlands gravel bed at the Interstate 90 site shows agates and petrified wood that have been sandblasted by winds to a nice polish.**

After lunch, I was on my way north. I wanted to check out one more place before driving east toward home. My route took me through the Black Hills and past Crazy Horse Monument and Mount Rushmore. The scenery is great, with dense forests of pines along the way. It was during the Sturgis motorcycle rally, and I saw thousands of motorcycles going in both directions on the highway. Maybe next year, I'll join them on my Goldwing.

When I arrived at the bustling city of Wall, I stopped in at the BLM office on Main Street, picked up a few brochures, had a chat with a lady ranger and was on my way.

My next stop was six miles east of Wall at I-90 Exit 116. Here is a northern section of Buffalo Gap National Grassland, and it's somewhat different from the southern site I had left earlier. The gravel road meanders out over a flat plain a short way (approximately one mile) from I-90, and after making a 90-degree left turn, crosses a cattle guard. You are now in typical badlands scenery; scenery that rivals the national park, which by the way, is but a mere five miles south of I-90 at this point.

I parked in a flat place and admired the surroundings. I had the place to myself. The view is spectacular, and well worth the short drive to see it. Here and there, exposed gravel beds cling to the sides of these multicolored hills. Some have been washed down into shallow valleys and scattered about. I found agates here, but of a different type than at the previous site. Coal black petrified wood lay everywhere I looked. Most pieces do not show growth rings. They're polished to a high sheen from wind-blown sand and known as dreikanters. The road evidently also serves as a ranch road, although I didn't see any cattle. This is wide open range, with no fences beyond the cattle guard that I could see.

The agates here are denser. I found few that show any translucence. They range in color from white to dark brown, gray, amber, blue, and black. Many fill the palm of my hand. I also picked up a selection of shiny, golden brown flint nodules, another member of the chalcedony family and the same type of stone that the early Native Americans made their tools and weapons from. I couldn't resist a grapefruit-size rose quartz nodule. It's a very dark reddish purple. It should reveal beautiful patterns when sliced.

The sun was nearing the horizon when I returned to I-90. It had been a fantastic rockhounding adventure. The weather cooperated, the scenery in South Dakota was picturesque, and collecting in Buffalo Gap National Grassland was spectacular! It has few rivals. I had merely scratched the surface, so to speak, but I had a great time. The grassland is there waiting for you. It's vast and it's beautiful.

# Adventures in Hawaii

Even the editorial staff of *Rock & Gem* gets to go on vacation now and again. So I decided my vacation should be to see the volcanic action on the Hawaiian Islands.

You are undoubtedly aware that those islands are in an ongoing island-building process of volcanic eruptions from a hot spot in the Pacific Floor Plate. To actually see red-hot lava flowing from a rift in the Earth's crust, continually forming new land and covering the old, is a kick.

Flowing lava is indiscriminate; it does not deviate from its path just because a house or road happens to be in the way! It simply creeps, sometimes dashes, along ignoring the efforts of humans to change its flow. Turn fire hoses on the face of flowing lava, and it develops a crust and continues to flow underneath. During World War II, an eruption in Italy threatened and eventually engulfed a town. The Air Force tried bombing the flow to stop it. Nice try!

Sometimes, a flow will split and go around a structure or even a town that is in its path. But why take a chance that Pele, the goddess of volcanoes, will take pity on you? Build somewhere else!

If you think Pele is only a figment of someone's imagination, talk to some of the locals in Hawaii! They have high respect for this unpredictable lady, especially when she acts peeved. Pele's legend is fascinating. She was a goddess skilled in making and controlling fire. She was a bit of a wild one, however, setting off volcanic action and fires indiscriminately. This caused Namaka, the goddess of the ocean, charged with putting out Pele's fires, much annoyance. To resolve this problem, Pele was consigned to a secluded place where her fires could cause no harm. Today, we call that secluded place Hawaii.

Pele has an effect on the locals, sometimes profoundly so. She appears to the locals to give them a chance to avoid destruction. Before every major eruption, Pele appears as a wizened old woman walking along a road. Those who treat her with respect suffer no volcanic wrath, but those who ignore her soon find red-hot lava on their doorstep. And any person who helps himself to some of her volcanic possessions, like pieces of lava or jars of black lava sand, may suffer her wrath in the form of a curse. But she is not always vindictive and cruel. Pele is also credited with a sense of humor, which you'll see expressed by my brief Hawaiian adventure.

If you think her curse is also a figment, talk with Hawaii's park rangers. You may be surprised to learn that thousands of island visitors who have collected pieces of lava or vials of volcanic sand have reported suffering Pele's wrath. In hopes of appeasing her, many of these people later returned their purloined goods to the National Park Service on Hawaii, begging the rangers to put the loot back where it belongs. Notes accompanying the black booty often describe the misery that descended on them after "stealing" some of Pele's treasured lava.

For example, one guy who innocently collected some black sand went home, was immediately dumped by his fiancée, and lost his job. His pet died and he became a drunk. Even the Feds grabbed him for some minor violation. He sent the black sand back!

On my trip, I experienced evidence of Pele's curse and sense of humor. As we were cruising back from Hawaii, our ship had to change course. Instead of making a stopover in Mexico, we sailed directly to San Diego. A fellow on the ship had had a sudden heart attack and had to be helicoptered off to the hospital. Someone said the fellow had taken one of the volcanic mountain hiking tours offered by the cruise line and maybe he had overtaxed his heart. I wondered whether he had accidentally, or purposely, picked up a bit of Pele's lava rock on that hike!

**Turquoise is once again a fashion favorite—as a stone in jewelry and as a color in women's clothing.**

My own experience actually turned out to be minor, maybe even one of Pele's jokes. All I did was take some pictures of flowing, red-hot lava. I had not collected even a grain of lava rock, because Arizona lava rock isn't a heck of a lot different than Hawaii's. After a day of sightseeing, including our helicopter flight to see the lava flows, we decided to have an oceanside dinner before returning to the ship. We found a nice place where we could enjoy the crashing of waves as we ate. A railing held a plastic shield to protect us from spray.

I paid for the meal, and as I was putting my wallet away, something knocked that wallet out of my hand. Normally, it would have fallen to the floor. Unfortunately, there was a small gap between the bottom of the railing and the floor. Instead of falling innocently to the floor, something caused that wallet to bounce right through the tiny gap under the railing and into the ocean!

Can you imagine what it feels like to look down into the ocean and see all your money, credit cards, picture ID, driver's license, and important papers gently bobbing on the outgoing tide? In a panic, I dashed out a side door of the restaurant, climbed down the sea wall, and plunged chest deep into the surf. By hanging on to the pilings, I was able to force my way through the surf to where I had last seen my wallet. By the time I got there, the wallet was gone!

Standing at the railing, my wife yelled that the wallet was still floating, but had moved out to sea. She pointed in the general direction, and I pushed on, walking out until the water was so deep I had no choice but to start swimming. I couldn't see the thing, as the waves were about 3 feet high and were rocking and rolling pretty well. Miracle of miracles, as I swam along, I found my wallet serenely floating on the waves with all my now soggy money, stained pictures, credit cards, and picture ID. Grabbing the wallet, I turned, and there floating in front of me was my glasses case! It had popped out of my shirt pocket during the swim; I had not divested myself of anything before making my plunge.

As I swam toward the restaurant, patrons of the bar next door directed me to a staircase leading from the water. I headed in that direction among the cheers and applause of both the bar patrons and the restaurant guests who were lined along the railing watching this impromptu water show. Was Pele just giving me a little warning about being too liberal with the camera? Was she just playing a little joke on me because of my high interest in Mother Earth? Or was it all just an accident with a happy ending?

One of the highlights of my Hawaiian visit was to spend an afternoon at the Lyman Museum on Hilo. David Lyman was a preacher who came to Hawaii and stayed. He started a boys' school, built a home, had children, and generally gave much to the local population in the way of religion, education, and useful skills. His philosophy was simple: Everyone should be educated with skills that will see them through life. He taught home building, furniture making, and faith in God.

When his old house, built in the 1800s, was going to be torn down, a descendent paid to have it moved and turned into a museum. It stands today near downtown Hilo, with its original gorgeous furniture and even some of the original wallpaper!

My particular interest at the Lyman Museum was with the mineral collection, which is housed in a fine modern facility next to the original Lyman home. There is a superb and well-displayed regional shell collection that I found as fascinating as the minerals.

The mineral collection consists of several windowed displays with large specimens on various-sized pedestals. The labeling is difficult to read, but the specimens themselves need no help, for they are fine examples of dozens of species. A small suite of large zeolite specimens is scattered through the displays. They are in contrast with extremely colorful species from all over the world. One eye-catcher is a large, domed specimen of bright blue-green smithsonite from the Kelly Mine in Magdalena, New Mexico. It is one of the best I've seen and is typical of the very fine zinc carbonates that came from this mine decades ago.

Another very attractive specimen is a kunzite some 15 inches long. The crystal, embedded in feldspar matrix, was naturally broken while still in its original gem pocket underground, possibly by earth movements that occur during and after crystal formation. A more plausible theory is that turbulent solutions invaded the original gem pocket, disturbing and fracturing existing crystals. The broken crystal end then was healed by the mineral-rich solutions. The most exciting theory involves the buildup of heat in a closed pegmatite crystal pocket until a violent explosion occurs, tearing crystals asunder and scattering shards around the pocket. Later solutions heal the broken ends.

One of the interesting things about the collection in the Lyman Museum is that it is dated. Many of the specimens displayed are superb examples of the finer species that were popular and available in the latter half of the 20th century, but there are few examples of things that have been mined in the last decade, such as a nice rhodochrosite from the recent working at the Sweet Home Mine in Alma, Colorado. Along with it is a vanadinite clearly dug decades ago in Arizona.

One of the more attractive common species on display is a magnificent white group of tapering, pointed aragonite crystals. These particular choice calcium carbonates were found in a magnesite deposit in Podrecany, Slovakia. Its crystals rank among the better examples of aragonite for crystal form and size. The specimen on display at the Lyman is some 7 inches long and is equal to the largest of these snowy Polish beauties!

While the Lyman Museum is decidedly off the beaten path for most rockhounds, anyone who ventures into Pele's domain would do well to spend a couple of hours here enjoying the specimens on display, the movies on volcanic eruptions, and the superb shell collection.

I may have taken too many photos of Pele's volcanic domain on my recent Hawaiian vacation.

A large, colorful Afghanistan kunzite specimen with feldspar and quartz is displayed at the Lyman Museum in Hilo, Hawaii.

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I'm sure it will come as no surprise to you that one of the Southwest's favorite and most revered gemstones is back in favor again! Turquoise has been popular since before recorded time, though its most exciting peak in popularity was in the latter half of the 20th century; the wonderful gemstone was mentioned as a good investment in the *Wall Street Journal* and was immediately "discovered" by fashion experts!

Those same experts are at it again. The blue color of turquoise is one of the "in" shades being employed by designers for the garment industry, in blouses, skirts, slacks, and a whole range of outerwear. And how better to complement this clothing than with jewelry made with the real gem? Most popular these days are necklaces strung with large, rounded turquoise nuggets. These are often complemented with bracelets of smaller nuggets strung either on wire or leather.

The turquoise being used today is mostly treated or, unfortunately, synthetic. You can't blame people for using what's available. The turquoise-rich upper zones and oxide zones of many of the older copper deposits have long since been depleted. There are still sources of natural turquoise, but these supply only a fraction of the demand now that turquoise is back in favor.

The saving grace these days is some of the huge copper deposits in China, now online and producing some very nice spider web turquoise. But again, the demand is huge and the supply minimal, so every scrap of turquoise, no matter how soft and pale, has to be treated for use. That turquoise has been revered by countless civilizations over the millennia stands as mute evidence of this lovely gem's everlasting allure.

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Don't forget the East Coast Gem & Mineral Show, Aug. 12-14, 2005 in West Springfield, Massachusetts, one mile west of Interstate 91. Admission has been reduced to $5 and parking is also $5. See you there!